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CIVIL ENGINEERING.

On the Construction of a Rigid Suspension Bridge. By C. KÖPCKE, Geestemünde, Hanover.

From the Civ. Eng. and Arch. Jour., Jan., 1861.

THE vertical vibrations to which the common suspension bridges are to a great extent subjected have much restricted the application of these structures, and rendered them unsuitable for railway purposes. Several proposals have lately been made to stiffen the suspension bridges, but none of these appear to answer the purpose in a simple and safe manner. The construction to be here described, as shown in Fig. 1 [next page], consists essentially of two rigid beams suspended on the pillars, and connected by means of hinges, and so curved as to sustain only a strain similar to that of a chain when loaded equally over the whole length, but being strong and rigid enough to counteract the undulations resulting from a heavy transit load (Fig. 2). The calculation of the strain in the different parts is based on the theory of the line of tension, which has here a similar application as the line of pressure in the calculation of arches. The essential difference, however, is this: that in an arch, several lines of pressure can always be drawn, every one of which gives a different result in respect to the strain on the material, so that it remains undecided which line of pressure will actually come into operation. Moreover, in an arch, the line alters its form according to the tempe-

rature, and in consequence of the starting points at the crown and in the abutments not always being the same.

FIG. 1.

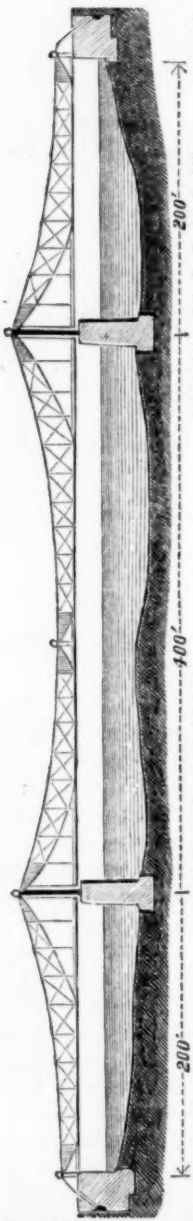


FIG. 2.

In using hinges which will allow of the beams moving vertically by change of temperature at the points of suspension, as well as in the middle of the opening, the line of tension is at once fixed; it must necessarily pass through those three points, and its form can be ascertained with the utmost precision for any position of the load brought upon the bridge.

Now, when the form of the line for a special case is found, it will be possible to calculate the strain on the main chain as well as on the bottom flanch, both being connected by lattice-work or diagonal bracing.

FIG. 3.

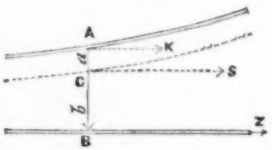
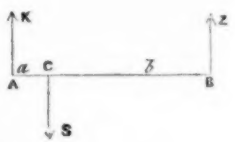


FIG. 4.



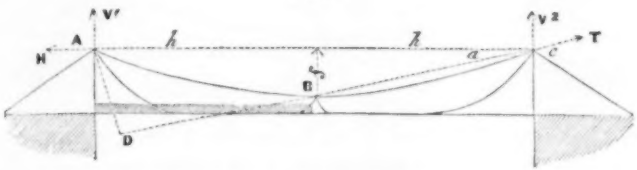
Let A (Fig. 3) be the main chain, B the bottom beam, and C a point of the line of tension calculated for a special case, having the distances a and b from the chain and the beam, respectively. The horizontal strain in the line of tension may be called S; that on the chain, K; and that on the beam Z; then there will subsist a relation between the different strains similar to that of a beam resting on two supports and being loaded at a certain point of its length (Fig. 4), viz:—$K \cdot a = Z \cdot b$, and $Z + K = S$, so that

$$K = S \cdot \frac{b}{a+b}, \text{ and } Z = S \cdot \frac{a}{a+b}.$$

To get the calculation of the line of tension as simple as possible, suppose both the constant and the moving load uniformly distributed over the horizontal projection, whence the line of tension will be a parabola. In case of the load not being spread over the whole length, the line of tension will be composed of parts of two different parabolæ. The tension of the main chain or rope when loaded on its whole length, is so easily determined, that it is not necessary to give the calculation, but to take under consideration here only the bottom

flanch and the lattice-work or diagonal bracing, when one-half of the span, or, what will be the same, one of the two suspended beams, is continually loaded with the passing weight, and the other half unloaded (Fig. 5).

Fig. 5.



Let the half-span be $= h$, and the height of the points of suspension above the junction in the centre $= f$, the permanent load $= q$, the moving load $= p$, per unity of length.

Now, we may assume the unloaded half $\overline{BC}$, considering its construction as a beam, to be a firm connecting piece between the points B and C, as it might also be effected by a rectilinear rope. The pressure on the support C, caused by the movable load may therefore be derived from the strain T of a rope $\overline{BC}$, supposed to be weightless. Produce the line $\overline{CB}$ to a point D, whence a line drawn normal to DC will pass through it, and let the length AD be equal to s, then we have the equation:

$$T \cdot s = \frac{p h^2}{2}, \quad \text{since } s = 2h \sin a,$$

$$\text{and } \sin a = \frac{f}{\sqrt{f^2 + h^2}}, \quad T = \frac{p h}{4f}\sqrt{f^2 + h^2}.$$

The vertical component of this strain will be $= T \sin a = \frac{p h}{4}$, and the horizontal component $= T \cos a = \frac{p h^2}{4f}$.

The permanent load q, uniformly distributed over the whole length, causes in each of the two supports a vertical pressure $= qh$, and a horizontal strain $= \frac{q h^2}{2f}$; we have, therefore, the whole pressure in A,

$$V_1 = qh + \tfrac{3}{4} ph = (q + \tfrac{3}{4} p)h,$$

and in C,

$$V_2 = \left(q + \frac{p}{4}\right)h;$$

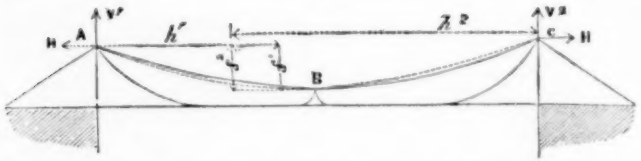
whereas, the horizontal strain throughout the whole length is

$$H = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}.$$

Having the value of HV_1 and V_2, it will now be possible to find the semi-chords, as well as the heights of the two parabolæ which compose

the line of tension and join in the middle hinge, whereby the line of tension will be entirely fixed (Fig. 6). As regards first the loaded

Fig. 6.



half, the horizontal distance h_1 of the vertex from the point A can be deduced from the vertical pressure in A, as follows:

$$(q+p)h_1 = V_1 = (q+\tfrac{3}{4}p)h,$$

therefore,

$$h_1 = \frac{q+\frac{3}{4}p}{q+p}h.$$

Further, the vertex of the parabola lies at a depth f_1 below the level of the points of suspension, to be found by the relation

$$f_1 H = (p+q)\frac{h_1^2}{2},$$

whence it becomes

$$f_1 = \frac{(q+\frac{3}{4}p)^2 f}{(q+p)\left(q+\frac{p}{2}\right)}.$$

Thus, the parabola which represents the line of tension in the loaded half can be drawn, the values of f_1 and h_1 being known. As regards the unloaded half, it is evident that the geometrical tangents to the line of tension at the middle hinge must be directed upwards towards C, because this hinge has to transfer the weight of $\frac{ph}{4}$. The vertex of the completed parabola, of which the line of tension between B and C forms a part, lies beyond the middle towards A, and as we call q the weight upon the unity of length in a horizontal distance from B equal to $\frac{ph}{4q}$, then the semi-chord h_2 of the parabola from C to its axis will be

$$h_2 = h + \frac{ph}{4q} = \frac{p+4q}{4q}h.$$

The rise f_2 of this parabola may be determined by the relation $H.f_2 = \frac{qh^2}{2}$, and substituting for H its value, it becomes

$$f_2 = f\frac{(p+4q)^2}{16q^2+8pq}.$$

Thus, the values f_2 and h_2 being known, the part of the parabola

which represents the line of tension in the unloaded half, is also determined.

By means of the relation between K, S, and Z, the strains on the chain and bottom flanch can now be determined for every special case. It is a matter of course that the most unfavorable mode of loading must be always assumed. In ascertaining, therefore, the strain of the chain, we have to consider the bridge as completely loaded, while only one-half of this load is to be taken into account in computing the tension of the lower member. To illustrate the case by an example, suppose

The moving load $p = 3500$ lbs.
The permanent weight $q = 2000$ lbs.
The span $2h = 400$ ft.
The height $f = 33\frac{1}{3}$ ft.
The height of the middle hinge above the bottom flanch = 8 ft.

Then the greatest strains on the chain and the bottom flanch are to be calculated as follows:—

In substituting the figures in the preceding equations, we get these results:

$h_1 = 168{\cdot}18$ ft. $\qquad f_1 = 34{\cdot}565$ ft.
$h_2 = 287{\cdot}5$ " $\qquad f_2 = 36{\cdot}76$ "

Let the middle hinge be now the point of origin, and the horizontal line through it the axis of abscissæ: then we get the following table of ordinates for the different lines of tension in each half of the bridge:—

Abscissæ (Foot).	Ordinates (Foot).		
	Total Load.	Partial Load.	
		Loaded half.	Unload. half.
20	0·333	1·056	1·71
40	1·333	1·154	3·80
60	3·000	0·274	6·25
80	5·333	1·583	9·05
100	8·333	4·419	12·21
120	12·000	8·231	15·71
140	16·333	13·022	19·56
160	21·333	18·790	23·80
180	27·000	25·536	28·39
200	33·333	33·333	33·33

The horizontal strain in the line of tension when the whole bridge is loaded, is equal to

$$\frac{(p+q)h^2}{2f} = \frac{(3500+2000)200^2}{2 \,.\, 33{\cdot}33} = 3{,}333{,}333 \text{ lbs.}$$

The strain at the point of suspension

$$= \sqrt{3{,}333{,}333^2 + (5500 \,.\, 200)^2} = 3{,}508{,}720 \text{ lbs.}$$

The horizontal strain in case of only one-half of the span being exposed to the moving load, is found to be $H = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}$, or, in figures, H = 2,250,000 lbs.

The strain at the point of suspension on the side where the bridge is loaded, amounts to

$$= \sqrt{2{,}250{,}000^2 + (168{\cdot}18 \,.\, 5500)^2} = 2{,}433{,}000 \text{ lbs.},$$

and on the unloaded side,

$$= \sqrt{2{,}250{,}000^2 + (287{\cdot}5 \,.\, 2000)^2} = 2{,}322{,}000 \text{ lbs.}$$

When the bridge is not loaded at all, the horizontal strain equals

$$\frac{q\,h^2}{2f} = 1{,}200{,}000 \text{ lbs.},$$

and the strain at the point of suspension,

$$\sqrt{1{,}200{,}000^2 + (200 \,.\, 2000)^2} = 1{,}265{,}000 \text{ lbs.}$$

If we allow now a strain of 8500 lbs. per square inch, then the section of the main chains (which may be three in number for a double line of rails) must amount to $\frac{3{,}333{,}333}{8500} = 392$ square inches, or for each chain 131 square inches.

Concerning the bottom flanch it must be remarked, that as it lies horizontally supporting the ends of the cross beams, the area of its section must be varied. At 20 feet distance from the middle hinge, we have the ordinate of the main chain = 0·333 feet, that of the line of tension on the loaded side = —1·056 feet; the depth of the bottom beam below that line = 8 — 1·056 = 6·944 feet. The horizontal strain in the line of tension, the bridge being loaded unequally, = 2,250,000 lbs. This strain is transferred partly to the chain, partly to the bottom beam, in proportion to the distances of each from the line of tension, so that the strain coming on the beam equals

$$z = \frac{0{\cdot}333 + 1{\cdot}056}{8 + 0{\cdot}333} \,.\, 2{,}500{,}000 \text{ lbs.}$$

$$z = 375{,}000 \text{ lbs.}$$

At 60 feet distance from the middle hinge we get

$$z = 685{,}000 \text{ lbs.}$$

At 100 feet distance, z = 564,000 "

At 140 feet distance, z = 331,000 "

Thence to the point of suspension a separate iron is applied, of such a form that the strain to which it is exposed remains constant. On this part of the bridge the roadway is merely supported by suspension rods (fastened on the main beams), as no diagonal trussing is required. These beams have no support at the ends, but provision must be made that no horizontal oscillation can result from their being at liberty to move laterally. On the unloaded side of the bridge, pressures result in the partly-horizontal partly-curved bottom beam, because the line

of tension passes above the main chain; but these pressures, which may be found by the above table in the same manner as the strains are found, are of no particular interest, since they become smaller than the strains at the same points when the bridge is loaded on this side. If it be considered preferable to avoid all pressure in the bottom beam, it would only be necessary to draw the elevation of the chain according to the line of tension in the unloaded side in case of single-sided loading; the consequence hereof would be that the bottom flanch would partake of the strain also in case of uniform loading, and therefore require to be made stronger, but always considerably less than double what is here calculated.

The differences of strain in the bottom member are compensated by the lattice-work or diagonal bracing (shearing effect), and may be calculated here in a similar way as in ordinary beams. This shearing effect is here considerably less than in beams without strain in the axis, therefore the lattice-work can have small dimensions and great openings. Plate iron of such a thinness as would be requisite here is hardly applicable; but it may be mentioned, that with respect only to the shearing force, the vertical plates (that is, of all three beams) would require a weight per square foot of elevation—

At 20 feet distance from the middle hinge, of .	3·057 lbs.
At 40 feet distance, . .	2·393 "
At 100 feet distance, only . .	0·064 "

supposing the strain on the square inch to be 5000 lbs.

In arranging diagonal braces with 45° inclination, so as to resist the pulling forces only, and vertical posts against the crushing forces, this brace-work would require a weight nearly five times as much as that just calculated for plate iron.

The weight of a bridge of 400 feet span, approximately calculated, stands thus:—

	lbs.
Main chains, of an average sectional area of 136 square inches, 3 . 136 . 400 . 3, . . .	489,600
Bottom flanch and beam carrying the railway— 2 . 3 . [60 ft. (40 sq. ins. + 60 sq. ins.) + 140 ft. . 80 sq. ins.] =	103,200
The brace-work has an average weight of 6 lbs. per superficial foot of the total area between frames— 3 . 2 . 2100 . 6 =	86,400
Cross-beams, arranged in plan like a net, to stiffen the bridge laterally against the effect of wind and passing loads—320 in number, 21 feet long, and weighing 30 lbs. per foot run, .	201,600
Suspension-rods, 1450 feet at 6 lbs., . . .	8,700
Wind-braces between the main chains, . . .	10,000
Rivets, &c., ...	30,000
Total weight in lbs., . .	929,500

Making per foot run, $\frac{929,500}{400} = 2324$ lbs.

Besides this, should be included 200 lbs. per foot run for rails, sleepers, and planking, increasing the constant weight to 2524 lbs. per foot run, whereas, before, only 2000 lbs. was assumed. This dif-

ference properly demands a fresh calculation under the supposition of 2524 lbs. constant weight; but, as it is not intended here to give an exact estimate for a special case, it will suffice to remark that, in keeping the dimensions found above, the strain on the main chain would increase from 8500 lbs. to

$$\frac{3500 + 2524}{3500 + 2000} \cdot 8500 = 9290 \text{ lbs. per square inch of section.}$$

It is evident that this system is also applicable to arched bridges, and that here the same advantages are to be obtained as in applying it to suspension bridges. The principal defect of wrought iron arched bridges as they are now usually constructed (and the best model of which is considered to be the Pont d'Arcole, Paris, projected by Cadiat and Oudry), cannot be obviated without the introduction of a hinge in the centre of the arch. For, if the arch is made somewhat high in the soffit in order to get it sufficiently rigid, the structure will be endangered by the influence of temperature. The increase of temperature produces an extension of the whole arch and a rise in the middle, the consequence of which will be that the upper flanch becomes more lengthened than the lower one. The amount of these mutations effected by the changes of temperature depends on the height of the arch. The Pont d'Arcole has ribs of only small rise in the centre, and therefore the influences of temperature are here less considerable; but this advantage is obtained at the expense of the strength of the ribs, which are more liable to deflect when a load passes over the bridge. This disadvantage is fully obviated by introducing a hinge in the centre—the arch can in that case freely extend and rise without being exposed to a dangerous strain, and the height can be made great enough not to admit of any detrimental deflection. As above defined, hinges should also be introduced at the abutments.

All uncertainties respecting the amount of the strain on the material, are now entirely removed. The amount of pressure can, therefore, be distinctly determined, so that all strains to which any parts of the structure may be subjected can be computed beforehand with exactness.

Translated for the Journal of the Franklin Institute.

Examination of some Questions relative to Transportation. By M. LAMARLE, Chief Engineer "des Ponts et Chaussées." Translated by J. BENNETT.

(Continued from page 298.)

We have endeavored to determine it in the ordinary circumstances of navigation, and we will indicate succinctly the principal results to which we have arrived in the case of animate motors, which the usual navigation employs almost exclusively upon our canals. They lead to the following rule: the number of motors to be employed to insure a minimum of expense should be equal to the ratio of price of hire of

boat to that of each motor. We may then easily deduce the velocity and net cost corresponding with this condition.

The following table indicates these values, for the different classes of boats, in two distinct cases:

1. The actual state of navigation, with a depth of 1·65 m. (5·41 ft.) and section of 18 square metres (21·5 square yards).

2. The increase in draft of water, which is now 6·56 ft. upon some lines, should approach a water section of 24 square metres (28·7 square yards).

Designation.	Tonnage.	Going loaded.			Returning empty.			Total per ton going and returning.	Remarks.
		Velocity.	Expense per kilometre and per		Velocity.	Expense per kilometre and per			
			boat.	ton.		boat.	ton.		
		m.	fr.	fr.	m.	fr.	fr.	fr.	
Small boats,	25	0·73	0·319	0·0128	0·90	0·200	0 0080	0·0208	*a*
Medium boats,	100	0·73	0·534	0·0053	0 90	0 262	0·0026	0 0079	*a*
Bilanders,	190	0·78	0·679	0·0036	0·90	0·324	0 0017	0 0053	*a*
Great boats,	225	0·62	0 797	0·0035	0 90	0·293	0 0013	0 0048	*a*
Small boats,	25	0·82	0·305	0·0122	0 90	0·200	0 0080	0·0202	*b*
Medium boats,	100	0·79	0 492	0·0049	0 90	0·262	0·0026	0 0075	*b*
Bilanders,	190	0·85	0·621	0·0033	0 90	0·324	0·0017	0·0050	*b*
Great boats,	270	0·60	0·834	0·0031	0·90	0·293	0·0011	0·0042	*b*

a Actual conditions: depth 5·41 ft., section 21·5 sq. yds., hauling with horses.

b New " " 6·56 " " 28·7 " " "

Note.—In the columns of velocity multiply by 2·236 for number of miles per hour. Multiply francs per kilometre per ton by 29·9 for cents per ton per mile.

These results apply to planes of water without locks and without velocity. To appreciate the increase of expense due to locks, it suffices to convert into kilometres the time consumed by the boat in passing them.

If we designate by d the space between the locks, by v the velocity of the boat, and by t the time lost at each lock, we shall have, for the time of passing the reach and lock, $t + \frac{d}{v}$ instead of $\frac{d}{v}$; whence, for the co-efficient of increase of expenses, $1 + \frac{v\,t}{d} = B$; the space corresponding to the passage of the lock is $v\,t$.

Generally we have $t = 3600''$, $v = 0{\cdot}55$ m. (1·8 ft.), whence

$$B = \frac{1{\cdot}98 \text{ k.}}{d} + 1, \text{ or } \left(B = \frac{1{\cdot}23 \text{ miles}}{d} + 1\right).$$

The expenses of navigation will thus be doubled for reaches of a

length of 1·98 k. (1·23 miles), quadrupled for $d = 0{\cdot}66$ k. (0·41 miles), and decupled for the smallest reaches $d = 0{\cdot}22$ k. (0·136 miles).

This cause of expense may be lessened in many ways:

1. By increasing the number of lock tenders, to hasten manœvring and to reduce the value of t.

2. By concentrating in each reach the motors employed in hauling, so that the boats only may lose the time consumed in passing the locks.

The first means would furnish upon frequented canals economies superior to the excess of expenditures which it would cost;* the second would reduce by about one-half the expense due to passing the locks; the use of these two means constitutes, then, an element of economy worth mentioning.

17. We have also sought to determine the influence exerted by the velocity of currents upon the cost of navigation, and we give in the following table the results applicable to the greatest sections and the largest boats.

Velocity of current.	Velocity of boat.	Expense of Navigation.				Force required.	
		Ascending.		Descending.		Ascent.	Descent.
		Co-efficients.	Absolute values.	Co-efficients.	Absolute values.	Increase.	Decrease.
metre.	metre.		franc.		franc.		
0·00	0·60	1·00	0·834	1·00	0·834	1·00	1·00
0·20	0·64	1·40	1·168	0·73	0 609	1·94	0·54
0·40	0·72	1·87	1·559	0·53	0·412	3·48	0·28
0·60	0·85	2·42	2·018	0·41	0·342	5·84	0·18
0·67	0·90	2·62	2·185	0·30	0·325	6 85	0·15

The usual velocities of the canaled rivers of the North are comprised in the limits of this table; it will thus admit of our accounting for the increased cost due to currents. Thus, for a river with a velocity of 0·2 m. (or 0·447 miles per hour) the co-efficients in ascending and descending are respectively 1·40 and 0·73; each kilometre ought then to be reckoned as 1·40 k. in ascending, and 0·73 k. in descending.

18. We might thus determine with an exactness sufficient for practice, the cost of navigation upon the mixed routes, comprised by the rivers and canals, as well as upon the most part of the great lines which are in special competition with the railroad.

We find, in applying the calculation to the trip from Mons to Paris, whose absolute length is 330 kil. (217·48 miles), that it is equivalent to 492·20 k. (305·84 miles) in going loaded, and to 465 k. (289 miles) in returning empty.

* An aid placed at each lock would gain a quarter of an hour per passage, and would cost 450 fr. per year. For a boat traveling 15 hours per day and costing 16 frs. (haulage included) a quarter of an hour is worth $\frac{16}{60} = 0{\cdot}27$ frs. The expenses will then be covered when the circulation exceeds $\frac{450}{0{\cdot}27} = 1667$ boats.

We might establish, according to these bases, the net minimum price of these transportations per ton per kilometre.

GOING LOADED.—Proportion of the increase $\frac{492\cdot20}{350\cdot00}$			= 1·406 fr.
The net minimum price found above is 0·0031 fr. per ton per kilometre (·0927 cents per mile) loaded upon a plane without lock and without velocity, and we should, therefore, reckon for a mixed line similar to that from		fr.	cts. per mile.
Mons to Paris, 1·406 × 0·0031 fr.		= 0·0044	= 0·1315
RETURNING EMPTY.—Proportional increase $\frac{465\cdot20}{350\cdot00}$			
= 1·33; the net minimum price being 0·0011 fr. (·0329 cts.), we shall have for the mixed line 1·33 × 0·0011 . . .		= 0·0014	= 0·0418
Sum,		0·0058	= 0·1733
When, by a better organization of stoppages, we shall have arrived at three trips per year, the number of days of navigation may reach 275 instead of 330, whence results a new reduction of about 17 p. ct., or		0·0010	= 0·0299
Leaving,		0·0048	= 0·1434
To which we should add, for general expenses, 0·62 franc per voyage, and for 350 kilometres, or per kilometre, . . .		0·0018	= 0·0538
Total minimum expense,		0·0066	= 0·1972
At present the cost of navigation upon this line is		0·0163	= 0·487
Comparing it with the net minimum price found above, . . .		0·0066	= 0·197
We see that it is possible to still economize per ton and per kilometre, . . .		0·097	= 0·290
Or per ton, for a voyage of 350 kilometres,		3·395	= 63·14
And for a mean traffic of 1,000,000 tons upon this line, . . .		3,395,000 fr.	= $ 631,470

Such, in this view alone, is the margin yet left for lowering the net cost of navigation. We should have found it much higher, if instead of taking for a type a route remarkable for its economical management, we had considered the lines on which this day is expended 0·02 fr., 0·03 fr., and 0·04 fr. per ton per kilometre.

We may, otherwise, immediately appreciate a part of the economies to be realized in the trip from Mons to Paris; we know that a mean of the boatmen makes less than three trips per year; but in reckoning upon this maximum figure, we find, in deducting from the total number of days of navigation, . . 275

The days of wharfage for two voyages, the last being charged to the stoppage, .	40
That the number of days sailing is .	235

Which answers to a trip of 2100 kilometres (1305 miles) only for three voyages, going and coming, and gives per day a mean trip of hardly 9 kilometres (5·59 miles).

Such a trip should be made in about 6 hours, locks and currents included, and it follows that of the 15 hours of the mean trip but two-fifths only are utilized. There are then considerable incidental expenses, which it is possible and important to annul. The material of the boating, so little utilized, far exceeds the actual need; this reservation is certainly an advantage which suffers it to live during the perfecting of its processes; but this essentially transitory resource will be destroyed in a few years, if the business of water transportation does not find, in an indispensable progress, the means of assuring its future existence upon the only solid basis, the economy of net cost.

19. In the above normal conditions, the expense of navigation with load, for reaches without velocity and locks, has been estimated per ton per kilometre at 0·0031 fr. (0·0927 cts. per mile.)

This sum may be relatively valued as follows:

Hire of boat, . .	0·0004	
Cost of equipment, maintenance, &c.,	0·0008	
		0·0012
Cost of hauling, . .		0·0019
		0·0031

The towing thus constitutes the most important element of expense, that upon which improvements and ulterior reductions should be made.

The tables relative to the influence of currents show how the cost of traction is raised on the ascent, when the velocity increases. It follows that upon rivers with great circulation, the ascending navigation must be frequently stopped, even in moderate freshets. It becomes, in fact, impossible to obtain the number of animate motors which may be needed. We cannot, for a temporary issue, double or triple the number of towing horses when this number is already great. Thus we have frequent interruptions upon the lines. Upon the Sambre there are sometimes detentions of fifty days in the year due to freshets. Such irregularities are doubly regretted from the increased cost and from the uncertainty which they bring in the working of these routes. They have caused us to recognise the utility of replacing horses by mechanical motors capable of developing at a given moment a power far superior to that of the ordinary work, and many trials have been made in this direction; steam has also been applied for traction upon the Oise and Seine, between Conflans and Paris; also between Dunkirk, Lille, Valenciennes, and the Capital. The moment is, perhaps, not far distant when these isolated applications may become general. They will, we believe, have chances of success the same as common navigation, provided we keep a moderate velocity and free the motors from the loss of dearly bought time at the locks.

Machines thus applied in reaches of sufficient length, for the towage of many boats working continually in both directions, may effectually

concur in reducing the cost of navigation, and thus create new progress.

The conditions of transportation upon canals and railroads will then be quite comparable; the motor will be the same, and the ulterior improvements will react upon both kinds of routes. Regularity, continuity of service, and constancy of net cost, will then be far better assured to navigation, which will maintain the two special advantages which characterize it:

A less resistance to motion.

A more advantageous ratio of useful load to gross weight.*

Without seeking for bulky merchandise, to rival the speed of railroads, it should certainly retain by water carriage the greater part of the transportations which have a more especial need of great economy in the net cost.

20. Such seems to us should be the issue of the struggle between each of the two ways, with the resources and their appropriate elements of progress. Both will then render to the public the services which it should expect from them, and industry will find in their regular co-operation, with the varied resources of which it has need, the necessary guaranties against all ulterior monopoly.

But, if this future is possible, if the day is to come for the improvements of which the navigable routes are so susceptible, in the triple point of view of tolls, improvement in material, and progress in their system of working; it must be admitted that its actual condition is far from satisfactory, and calls for immediate action. The so rapid encroaches of the railroad upon the domain of navigable canals verify its critical position, and we need not wonder we come to a comparison of the actual net cost upon these two kinds of communication.

Upon rivers and canals these prices vary from 0·027 fr. to 0·080 fr. per ton per kilometre, which by reason of their excess in length, comes to from 0·036 fr. to 0·107 fr. (1·076 cts. to 3·199 cts. per mile).

Upon railroads the price varies from 0·036 fr. to 0·180 fr. (1·076 cts. to 5·38 cts. per mile).

In fact, some persons relying upon data generally admitted at the first opening of railways, and upon what exists at present in England, where the price never falls below 0·06 fr. (1·794 cts.), have thought that the minimum rate of 0·036 fr. (1·076 cts.), applied to these freights, was not sufficiently remunerative. According to them, with such low tolls, railroads work at a loss, and cannot hold out long; but must retire from the field and raise their tariffs. We cannot admit this opinion otherwise than as contradictory to the well established facts of the present time. The superior commission upon railroad statistics, published in 1856 documents containing the relative estimate of their working expenses. The figures relative to the Northern railroad belong to the year 1853, so that probably there would now be a diminution in the net price which they established, if we take into account the improvements which have been introduced since then.

* To transport a useful load of 225 tons, there is required 250 tons gross weight upon the canal, and 375 upon the railroad; which gives respectively the ratios 0·90 for canals and 0·60 for the railway.

With the benefit of this reservation, the expenses for one kilometre may be valued as follows:

Nature of Expenses.	Expenses per kilometre for a train with 267 tons.			Expenses per ton per kilometre.		
	Total.	General Expense.	Special Expense.	Total.	General Expense.	Special Expense.
	fr.	fr.	fr.	fr.	fr.	fr.
General administration,	0·117	0·117		0·0004	0·0004	
Maintenance of Way,	0·359	0·209	0·150	0·0014	0·0008	0·0006
Working,	0·538		0.538	0·0020		0·0020
Traction,						
Personel Depots,	0·080					
Fuel, 23 lbs.	0·310					
"Alimentation,"	0·017					
Oiling,	0·009					
Mechanics, Stokers,	0·127					
Maintenan. of machin.,	0·253					
Maintenance of cars,	0·238		1·034	0·0038		0·0038
Divers expenses,	0·318	0·318		0·0012	0·0012	
Sum,	2·366	0·644	1·722	0·0088	0·0024	0·0064
Returning empty, half,	1·183	0·322	0·861	0·0044	0·0012	0·0032
Totals,	3·549	0.966	2·583	0·0132	0·0036	0·0096
				or cts. per ton per mile.		
				0·3946	0·1076	0·287

We must add to these expenses the interest and refunding of material used in the transportation, which amounts to 4182 fr. per kilometre for a traffic of 380,000 tons, to wit:

0·15 Merchandise, locomotive, at 115,000 fr. . .	17,250
6·57 Wagons at 3740 fr.	24,572
Total value, . . .	41,822

Which gives at 10 per cent. for interet and refunding per kil. 4182 fr.
and per ton, . . . 0·011 = 0·328 cts. per mile.

The complete price for transportation of oil by railroad may be thus established as follows:

General expense, . .		0·0036 fr. = 0·1076 cts. per mile.	
Special expenses proportional to traffic:			
Consumption personal maintenance,	0·0096		
Interest and refunding of material,	0·0110		
	·0206 =	0·6159	" "
Total, . . .	0·0242 =	0·7235	" "

We see then that at the minimum price of 0·036 fr. per ton per kilometre, there would still be in 1853 a profit of 0·0118 fr. (about 33 per cent.) for the Company. It might, without any loss, lower its tariff by 0·0206, the amount of special expenses proportional to the traffic.

At present the price of boating, deduction made for tolls, is at 0·0163 fr. upon the best worked lines, which amounts by reason of the

mean excess in length of navigable routes to 0·0220 fr. or (0·658 cts. per mile).

The railroad is working at this time in conditions the most regular, rapid, and economical. Far from being compelled to abandon the strife, it may, on the contrary, in proportion to the extension of its material draw to itself by new reductions of tariffs, a large portion of the general mass of freight.

It will be otherwise when the navigable routes, with their improvements, shall have attained the net price, above determined; the conditions of competition will then be established as follows.

Here follows a table, of which we give the general result, where allowance has been made for excess in length of navigable routes.

	Net price per ton and per kilometre.						
	Canals.			Mixed lines.			Railroad.
	Going loaded.	Returning em'y.	Total.	Going loaded.	Returning em'y.	Total.	
	fr.	fr.	fr.	fr.	fr.	fr.	fr.
General and Special Expenses.	0 0057	0·0018	0·0065	0·0065	0·0023	·0088	0·0242
			or cents per ton per mile.				
			0·1943			0·2631	0·7235

We shall then have

By the railroads, . . .	0·0242
By mixed lines, canals and rivers, . . .	0·0088
By canals only, . . .	0·0065

The relative economy by the navigable routes will then be for the mixed lines: 0 0154 fr. upon 0·0242 fr., or sixty-four per cent.

For the Canals: 0 0177 fr. upon 0 0242 fr., or seventy-three per cent.

Such figures are quite imposing and bring into relief all the effective power of navigable lines, and the utility of the measures necessary to develop it.

21. The author here gives three tables, showing the principal statistical facts, relative to the Northern rivers and canals.

The first shows the variations in price of freight in the principal directions; and proves in that from Mons to Lille, and to Paris, a reduction of more than 60 per cent. in less than twenty-five years; from Charleroi towards Paris, the reduction was 30 per cent. in twelve years.

The second table indicates the principal changes not long since effected in the assessment of tolls and the developments which have followed the reductions obtained in the expense of transportation; we give the most remarkable:

The lower Scarpe, where the mean tonnage equal to 260,000 tons

before the improved works, first rose to 448,000, and has continued to increase up to the maximum of 649,000, attained in 1855.

The Deule, whose circulation has risen from 134,000 to 600,530 tons since 1818.

The canal from Mons to Condé, upon which the tonnage reduced in 1826 from 489,000 to 191,000 tons, by the making of the Belgian canal of Anthoing, has risen constantly since, and reached in 1856 the enormous sum of 1,260,000 tons.

The Canal of St. Quentin, whose traffic varied from 50,000 to 1,050,000 tons between the years 1824 and 1855.

Finally, the Sambre, which scarcely carried 30,000 tons in 1836, has realized in 1856 a maximum of 708,860.

We do not believe there exists an example of greater development of traffic so rapidly obtained. The special nature of transportations upon the Northern Canals, where oil composes the majority (about four-fifths), explains the increase, which is connected with all industrial progress, thus stimulating and receiving the reaction of their development.

The same table also proves the retrograde movement which has begun to manifest itself upon some of the principal lines: the Deule, the Scarpe, the Mons Canal, and those of the Sambre. The unusual drought of the two last years, and the recent oil discoveries of Pas-de-Calais, have exerted, without doubt, some influence upon these results, but they are especially due to the competition of the railroad, which the extension of its material renders each year more energetic and powerful.

In the third table are entered the rivers and canals, prolongations of the Northern lines towards Paris, and having for a development of 957·6 kil. (593·7 miles) the useful work of two distinct periods; the one 1844, prior to the working of the Northern railroad; the other 1855, some years after its opening.

Notwithstanding the rivalry of this new route, the useful work of the navigable routes mentioned in the table has increased in this period of eleven years; it has risen from 348,944 to 589,128 thousands of tons to one kilometre, a relative increase of 69 per cent. It represents this day a quarter of the useful work of all the rivers and canals of France for an extent scarcely equal to the twelfth of their total development of 11,225 kilometres.

The mean rate of tariffs collected in 1844, at 16·03 fr. per thousand tons at one kilometre ($4·79 per mile); since 1849 it was reduced to 12·55 fr.; notwithstanding this reduction of 22 per cent., the total product of tolls has increased from 5,594,499 to 7,378,065 fr. This fact proves the potency of this tutelary measure, which has so rapidly converted into a profit of nearly 33 per cent., the losses immediately caused by the reduction of the fees of navigation. In 1858 the tolls on returning empty were suppressed in the basin of the Aa, of Escaut, and upon the Saint-Quentin canal; there will follow from this measure a new alleviation of charges which now burthen the transportations by water.

If from the total of tolls collected in 1855 and amounting to . . .	7,378,065 fr.
We deduct the cost of maintenance of the different routes, which amount to . .	1,100,000 "
There remains, . . .	6,278,065 "

This sum represents the excess of annual receipts above the expenses; the net product of navigable routes may, according to the different phases of competition, become the object of reductions, proportioned to the need of the strife. The above figures would indicate the superior limit of possible reductions, in case of necessity, if the circulation remained invariable. But as the constant effect of reductions of tariff, is to impress upon traffic a more rapid flight, it is not to be doubted, that we should by judiciously progressive abatements obtain still higher results, but we will count only upon the above figures.

The actual mean cost of the immense circulation of these navigation lines, is 16·65 fr. per thousand tons carried one kilometre. Now we have seen that even with animal motors, it would be possible to reduce the cost of navigation per ton per kilometre to 0·0066 fr. (0·1973 cts. per mile) or

For 1000 tons per kilometre, . . .	6·60 fr. or $1·97 per mile.	
In comparing the minimum price with the actual corresponding transportation, ...	16·65 fr. or 4·97 "	"
We have the economy to be realized by perfecting the material and working progress, . . .	10·05 "	$3·00

And this independent of ulterior reductions, which would follow on the introduction of mechanical motors. Keeping to the limit of 10·05 fr. and charging it to the actual circulation, we have a product of 5,910,736 fr., which evidently represents the inferior limit of advantages to be realized. It is certain that the tonnage will not remain stationary, but must increase from the two-fold effect of abatement of tolls, and economies in the cost of navigation.

Without losing sight of all the advantages resulting from these future developments, we see upon a basis of actual facts, that it is possible to arrive at a total reduction of 12,188,801 fr. upon the expenses of navigation, to wit:

Upon tolls, . . .	6,278,065
Upon cost of transportation, . .	5,910,736
	12,188,801

Now the total of expenses at the present time are as follows:

Tolls, ...	7,378,065
Cost of Transportation, . .	9,814,036
Sum,	17,192,101

Whence it follows that the realizable economy is equivalent to the *seven-tenths* of the actual expenses.

Such a result shows the value and importance of these ameliorations; the symptoms of decline evinced upon many of the most important lines

give to their research and progressive application an immediate interest for the prosperity of commerce and developments of industry.

From the past history consigned in the tables it is seen how productive are such improvements, and how quickly they are utilized by the transportation departments, responding thus with energy, by a continuous progress, to the protective measures of which it is the object. And it is hoped, that an attentive examination of them, will strengthen the opinion we have expressed upon the future in reserve for navigable routes, and shall be happy if these notes shall contribute in some respects to its accomplishment.

Railway Bridge over the Rhine.

From the Civ. Eng. and Arch Jour., April, 1861.

The great railway bridge over the Rhine at Kehl being nearly completed, experiments to test its strength were made on it a few days since. First, the two turning parts of the bridge were manœuvred, and were found to work admirably. That of the French side, which weighs not less than 350 tons, was moved with the greatest facility by eight men, then by four, and then only by two. Afterwards, a train, consisting of five locomotives and their tenders, the locomotives alone weighing 175 tons, and the whole forming a weight of nearly $3\frac{1}{2}$ tons per metre, passed over the line, and then remained stationary on the first part of the bridge on the French side; next, a locomotive and 15 wagons filled with stone, weighing about $1\frac{3}{4}$ tons per metre, was driven over, and was subsequently stationed for a time in the middle of the bridge; in the third place, the two trains passed over side by side, and were made to stand on different fixed parts of the structure; next, two other trains, each consisting of five locomotives, were also driven over the bridge side by side, and were made to remain together some time on the turning bridges and on other portions of the structure. The weight of these two trains was 350 tons, or nearly 7 tons per metre of the line covered. Lastly, these trains were driven at full speed in contrary directions, passing each other on the bridge. Throughout the whole of these experimental trials, the deflections of the bridge did not average more than from 8 to 10 millimetres, or between a third and two-fifths of an inch; the greatest deflection was equal to four-fifths of an inch, and in this case, the part thus depressed rose again to its former level, within a quarter of an inch. The results prove that the work has been well executed.

England connected with France by Railway.

From the London Builder, No. 932.

It is said that the Emperor of the French "has at last given his sanction" to the project invented by M. Favre, a Parisian engineer, for making a railway from Calais to Dover. This gigantic project comprises a tunnel under the Channel; length 19 miles. The engineer, referring to the intrusions of water in making the Thames Tun-

nel, states that nothing of that kind can be apprehended, as the ground is mostly hard rock. The company of speculators who have taken the matter up in Paris are estimating the utmost cost of the tunnel; and the works are to be executed at a fixed price, by contractors offering every guarantee of responsibility. The French Emperor's "sanction" is doubtless very requisite, on the French side, to the French speculators who are so anxious to "annex" us; but his sanction will scarcely do on the English side, however agreeable it may be for us to escape the roll of the Channel waves in crossing to the Continent.

MECHANICS, PHYSICS, AND CHEMISTRY.

Experimental Researches to Determine the Density of Steam at all Temperatures, and to determine the Law of Expansion of Superheated Steam. By WILLIAM FAIRBAIRN, Esq., F. R. S., and THOMAS TATE, Esq.

From the Lond. Edin. and Dub. Phil. Mag., March, 1861.

The object of these researches is to determine by direct experiment the law of the density and expansion of steam at all temperatures. Dumas determined the density of steam at 212° Fahr., but at this temperature only. Gay-Lussac and other physicists have deduced the density at other temperatures by a theoretical formula true for a perfect gas:

$$\frac{VP}{V_1 P_1} = \frac{459 + T}{459 + T_1} \quad . \quad . \quad (1.)$$

On the expansion of superheated steam, the only experiments are those of Mr. Siemens, which give a rate of expansion extremely high, and physicists have in this case also generally assumed the rate of expansion of a perfect gas. Experimentalists have for some time questioned the truth of these gaseous formulæ in the case of condensable vapors, and have proposed new formulæ derived from the dynamic theory of heat; but up to the present time no *reliable direct experiments* have been made to determine either of the points at issue. The authors have sought to supply the want of data on these questions by researches on the density of steam upon a new and original method.

The general features of this method consist in vaporizing a known weight of water in a globe of about 70 cubic inches capacity, and devoid of air, and observing by means of a "*saturation gauge*" the exact temperature at which the whole of the water is converted into steam. The saturation gauge, in which the novelty of the experiment consists, is essentially a double mercury column balanced upon one side by the pressure of the steam produced from the weighed portion of water, and on the other by constantly saturated steam of the same temperature. Hence when heat is applied the mercury columns remain at the same level up to the point at which the weighed portion of water is wholly vaporized; from this point the columns indicate, by a difference of level, that the steam in the globe is superheating; for superheated steam increases in pressure at a far lower rate than satu-

rated steam for equal increments of temperature. By continuing the process, and carefully measuring the difference of level of the columns, data are obtained for estimating the rate of expansion of superheated steam.

The apparatus for experiments at pressures of from 15 to 70 lbs. per square inch, consisted chiefly of a glass globe for the reception of the weighed portion of water, drawn out into a tube about 32 inches long. The globe was enclosed in a copper boiler, forming a steam-bath, by which it could be uniformly heated. The copper steam-bath was prolonged downwards by a glass tube enclosing the globe stem. To heat this tube uniformly with the steam-bath, an outer oil-bath of blown glass was employed, heated like the copper bath by gas jets. The temperatures were observed by thermometers exposed naked in the steam, but corrected for pressure. The two mercury columns forming the saturation gauge were formed in the globe stem, and between this and the outer glass tube; so long as the steam in the glass globe continued in a state of saturation, the inner column in the globe stem remained stationary, at nearly the same level as that in the outer tube. But when, in raising the temperature, the whole of the water in the globe had been evaporated and the steam had become superheated, the pressure no longer balanced that in the outer steam-bath, and, in consequence, the column in the globe stem rose, and that in the outer tube fell, the difference of level forming a measure of the expansion of the steam. Observations of the levels of the columns were made by means of a cathetometer at different temperatures, up to 10° or 20° above the saturation point; and the maximum temperature of saturation was, for reasons developed by the experiments, deduced from a point at which the steam was decidedly superheated.

The results of the experiments, which in the paper are given in detail, show that the density of saturated steam at all temperatures, above as well as below 212°, is invariably greater than that derived from the gaseous laws.

The apparatus for the experiments at pressures below that of the atmosphere was considerably modified; and the condition of the steam was determined by comparing the column which it supported with that of a barometer. The results of these experiments reduced in the same way, are extremely consistent.

As the authors propose to extend their experiments to steam of a very high pressure, and to institute a distinct series on the law of expansion of superheated steam, they have not at present given any elaborate generalizations of their results. The following formulæ, however, represent the relations of specific volume and pressure of saturated steam, as determined in their experiments, with much exactness.

Let v be the specific volume of saturated steam, at the pressure p, measured by a column of mercury in inches; then

$$v = 25{\cdot}62 + \frac{49513}{p + {\cdot}72} \qquad (2.)$$

$$p = \frac{49513}{v - 25{\cdot}62} - 0{\cdot}72. \qquad (3.)$$

In regard to the rate of expansion of superheated steam, the experiments distinctly show that, for temperatures within about ten degrees of the saturation point, the rate of expansion greatly exceeds that of air, whereas at higher temperatures the rate of expansion approaches very near that of air. Thus in experiment 6, in which the maximum temperature of saturation is 174°·92, the co-efficient of expansion between 174°·92 and 180° is $\frac{1}{190}$, or three times that of air; whereas between 180° and 200° the co-efficient is very nearly the same as that of air (steam$=\frac{1}{637}$, air$=\frac{1}{639}$), and so on in other cases. The mean co-efficient of expansion at zero of temperature from seven experiments below the pressure of the atmosphere, and calculated from a point several degrees above that of saturation, is $\frac{1}{438}$, whereas for air it is $\frac{1}{459}$. Hence it would appear that for some degrees above the saturation point the steam is not decidedly in an aëriform state, or, in other words, that it is watery, containing floating vesicles of unvaporized water.

TABLE *of Results, Showing the Relation of Density, Pressure, and Temperature of Saturated Steam.*

Number of experiment.	Pressure		Maximum temp. of saturation. Fah.	Specific Volume.		Proportional error of formula (2).
	in lbs. per sq. inch.	in inches of mercury.		From experiment.	By formula (2).	
			°			
1	2·6	5·35	136·77	8266	8183	$+\frac{1}{100}$
2	4·3	8·62	155·33	5326	5326	0
3	4·7	9·45	159·36	4914	4900	$-\frac{1}{350}$
4	6·2	12·47	170·92	3717	3766	$+\frac{1}{74}$
5	6·3	12·61	171·48	3710	3740	$+\frac{1}{123}$
6	6·8	13·62	174·92	3433	3478	$+\frac{1}{76}$
7	8·0	16·01	182·30	3046	2985	$-\frac{1}{50}$
8	9·1	18·36	188·30	2620	2620	0
9	11·3	22·88	198·78	2146	2124	$-\frac{1}{97}$
1′	26·5	53·61	242·90	941	937	$-\frac{1}{234}$
2′	27·4	55·52	244·82	906	906	0
3′	27·6	55·89	245·22	891	900	$+\frac{1}{100}$
4′	33·1	66·84	255·50	758	758	0
5′	37·8	76·20	263·14	648	669	$+\frac{1}{32}$
6′	40·3	81·53	267·21	634	628	$-\frac{1}{100}$
7′	41·7	84·20	269·20	604	608	$+\frac{1}{150}$
8′	45·7	92·23	274·76	583	562	$-\frac{1}{29}$
9′	49·4	99·60	279·42	514	519	$+\frac{1}{100}$
11′	51·7	104·54	282·58	496	496	0
12′	55·9	112·78	287·25	457	461	$+\frac{1}{114}$
13′	60·6	122·25	292·53	432	428	$-\frac{1}{108}$
14′	56·7	114·25	288·25	448	456	$+\frac{1}{58}$

Adopting the notation previously employed, and putting r for the

rate or co-efficient of expansion of an elastic fluid at t_1 temperature we find

$$r = \frac{1}{\epsilon_1 + t_1} = \frac{\frac{v_2 p_2}{v_1 p_1} - 1}{t_2 - t_1}, \qquad (4.)$$

where $\frac{1}{\epsilon_1}$ = the rate of expansion at zero of temperature. In the case of air, $\epsilon_1 = 459$.

The following Table gives the value of the co-efficient of expansion of superheated steam taken at different intervals of temperature from the maximum temperature of saturation.

Number of experiment.	Maximum temperature of saturation.	Temperatures between which the expansion is taken.		Co-efficient of expansion of superheated steam.	Co-efficient of expansion of air.
	°	°	°		
1	136·77	140	170	$\frac{1}{593}$	$\frac{1}{599}$
2	155·33	160	190	$\frac{1}{556}$	$\frac{1}{619}$
3	159·36	159·36	170·2	$\frac{1}{1550}$	$\frac{1}{618}$
		170·2	209·9	$\frac{1}{624}$	$\frac{1}{629}$
5	171·48	171·48	180	$\frac{1}{2000}$	$\frac{1}{630}$
		180	200	$\frac{1}{604}$	$\frac{1}{639}$
6	174·92	174·92	180	$\frac{1}{1960}$	$\frac{1}{634}$
		180	200	$\frac{1}{637}$	$\frac{1}{639}$
7	182·30	182·3	186	$\frac{1}{2350}$	$\frac{1}{641}$
		186	209·5	$\frac{1}{630}$	$\frac{1}{645}$
8	188·30	191	211	$\frac{1}{604}$	$\frac{1}{650}$
1′	242·9	243	249	$\frac{1}{517}$	$\frac{1}{703}$
4′	255·5	257	259	$\frac{1}{392}$	$\frac{1}{716}$
		257	264	$\frac{1}{600}$	$\frac{1}{716}$
6′	267·21	268	271	$\frac{1}{2150}$	$\frac{1}{727}$
		271	279	$\frac{1}{640}$	$\frac{1}{730}$
7′	269·2	271	273	$\frac{1}{2320}$	$\frac{1}{730}$
		273	279	$\frac{1}{551}$	$\frac{1}{733}$
9′	279·42	283	285	$\frac{1}{298}$	$\frac{1}{742}$
		285	289	$\frac{1}{533}$	$\frac{1}{744}$
13′	292·53	297	299	$\frac{1}{281}$	$\frac{1}{756}$
		299	302	$\frac{1}{638}$	$\frac{1}{758}$

Hence it appears, that as the steam becomes more and more superheated, the co-efficient of expansion approaches that of a perfect gas. The authors hope that these experiments may be continued, and that the results obtained at greatly increased pressures will prove as important as those already arrived at.

For the Journal of the Franklin Institute.

The Manufacture of Cast Iron Pipes. By Ed. Brandt, Esq.

(Continued from page 333.)

Secondly.—I will now consider the defects of "green sand moulds" and "green sand cores." This class of pipes are cast upon a level, and are run from each end.

The objects in using green sand are substantially these, viz: The saving of straw, the labor of making the ropes and putting them on the core bar, and drying the cores. If the cores are properly made there is much less risk of forming blisters; indeed, the ratio of pipes saved by this method far exceeds the "loam core inclined pipe." But this system has some drawbacks, and I believe that it is found, upon the whole, to be but little cheaper than the loam core in point of labor; but, as I before stated, it is a safer method than the loam core and dry sand mould.

To use green sand cores, the following conditions must be complied with:

The core sand must be very open or coarse, and used as dry as practicable.

The cores cannot be "sleeked," nor can they be blackened.

The sand must be put on the core bars by hand as lightly as possible, in order to adhere to the bar, and finished by sifting sand upon them as a finishing coat.

They require pouring very fast with sharp iron. These conditions are absolutely necessary, and if not complied with, will result in the blistering of the surface, or an admixture of sand and iron through the pipe. To make good pipes by this method, it is necessary to pour them quick and with sharp metal. To do this with "green sand cores" will be likely to produce the following results, viz: 1st. The core sand is coarse and dryish, and not sleeked, and in consequence, the hot iron will wash off a great amount of sand that is just sticking fast enough not to fall off, and will carry it into the pipes. And further, from the core not being sleeked or blacked, and being coarse, the hot iron will enter freely into the pores of the sand, which will fasten a heavy coat of coarse sand over the surface of the inside of the pipe. 2d. The pipe must be poured up quick with hot iron, so as to put on a sharp strain, to prevent blisters, and as the cores are soft they strain along the bottom; and as the sand of the core is pressed on the core bars by the fingers, there are frequently numerous small soft places which will strain most, thereby causing the inside of the pipe to be very uneven. The spring in the core bar is about the same as in a loam core.

The running surface is very great, about 150 ins. area; but this evil is modified to a great extent by running the pipe from each end. It being cast horizontally allows the dull iron and dirt to rise to the top of the mould, causing a liability of the pipes to blister or cold shut upon its upper surface.

It is evident that this class of pipes, like those with loam cores, have a *soft side;* the top is liable to be thinnest, and is cast with the dullest iron, and into this side is washed all the loose particles of sand that are washed from the unsleeked core; the light pressure which is put

upon the metal in the top of the pipe (probably not more than 2 lbs. to the inch,) and the large running surface unite to cause it to be blistered and "cold shut," as the amount of pressure is insufficient to press the iron compactly together along its whole length, when it is in the condition above described. Why not increase the pressure on the top of the pipe? If the pressure is increased on the top of the pipe, you increase it also on the bottom, and it is much more effective on the bottom, because the iron is hotter and more fluid, and thereby causes a still greater strain upon the bottom of the core, which being soft gives way and renders the inside of the pipe very rough and uneven, thereby causing a serious obstruction to the passage of water. The service obtained from this class of pipes, for the above reasons, will be much less than from those of the same diameter with smooth bore.

I have shown the difficulties to be met with in green sand moulding to be of a character which may lead to great doubts of the expediency of running so great risk as must needs be in using castings of that character. I have considered these difficulties under the following heads, viz :—

I. Their tendency to uneven thickness.

II. Their tendency to blow or blister.

III. Their tendency to be very weak upon the top or cope side, and the causes which led to the first of these, viz: their tendency to uneven thickness, being again subdivided in the following order, viz :—

1st. Spring of the core bar.

2d. Raising of the loam of the core upon the bar.

3d. Manner of securing the core.

4th. The necessity of setting them out of centre.

5th. Clamping.

THIRDLY.—I will now endeavor to show that these evils may be avoided by casting vertically.

1st. "Spring of the core bar." The core bar being placed in a vertical position cannot spring, as there can be no lift upon it or tendency to move in any direction.

2d. "Raising of the loam of the core upon the bar." The loam upon the bar, however loose, must be equal all round, the pressure of the iron being the same upon all sides, at all times during the "pour."

3d. "The manner of securing the core." As there is no tendency for the bar to move from the position in which it is placed, it only remains for the mechanic to make such arrangements as to insure its centering properly, which is done by having the lower end of the core bar turned to fit a corresponding opening or seat, which effectually prevents its getting out of centre, while the upper end being in sight can be easily adjusted and set to a gauge. Hence, there is no more excuse for the core being out of centre than there is for the pipe being improperly made from any other cause. It, however, may be of uneven thickness, though the cores may be centered properly, should the mould be crooked; but this, like the above, is not a natural difficulty, but is the result of carelessness or negligence of inexperienced operators. An effectual check may be put upon that objection by requiring them to be within certain limits, and rejecting any that should

be beyond them; and as there are no natural or mechanical difficulties to surmount, proper care would soon rectify it.

4th. "The necessity of setting the core out of centre." As the cores have no tendency to change their position whilst the pipe is being cast, as a consequence there can be no necessity for setting them out of centre in order to insure an average pipe; it would indeed have an opposite result.

5th. "Clamping." Inasmuch as the flasks are clamped before they are "rammed," no difficulty from this cause can arise.

II. I next consider their inability to "blow" or "blister."

1st. In casting vertically, the hot iron is run on all sides of the core at the same time, and consequently, there is no point at which the iron is in a "duller" state than in another.

2d. If there should be, the "dull" iron would naturally rise on top, and would be in a position to catch the hot falling iron; and as a stream of fluid iron continuing to fall for a short time upon cold iron is capable of bringing it into a fluid state, it must necessarily have the effect of keeping the top surface of "the cast" in the "sharpest" possible condition.

3d. The pressure is run up very quick, and the running surface very small. This effectually avoids blisters by pressing the iron compactly whilst it is "sharp," and holding it there so firmly that the gas from the core more readily makes its way to and out of the core-bar than it can displace the iron in the mould.

It will be seen by comparison that the running surface of a 6-inch pipe, cast vertically, is about 10 square inches, and the running surface of a pipe of the same diameter, cast at an angle of about 10°, will be about 4½ times that amount, and being only about two feet from the lowest to the highest point; whereas, the vertical pipe is its length (say 9 feet), but one-third of the inclined pipe will have an elliptical running surface of six and-a-half inches diameter one way, and three feet one inch the other; this surface will vary in width from one-half to one and-a-half inches, giving a running surface of 72 ins. area. Thus, it will be seen that the part of the pipe which is usually blistered, is filled more than seven times as quick in a vertical mould than it is in an inclined one, *i. e.*, supposing the two pipes to be of the same length and diameter, and cast in the same period of time. And further, I repeat, that instead of having the dull iron all driven to one side of the pipe, you have hot iron dropping into the cast upon all sides of the running surface, varying from 9 feet, or the length of the pipe, to 0. Again, when the vertical pipe is cast there will be from 12 to 15 pounds pressure per inch in the middle of the length of the pipe (9 feet), whilst the inclined cast has but 3 to 5 lbs. per inch.

III. "The tendency to weakness on the cope side." There being no cope side, this weakness is entirely avoided; in other words, there is no particular point of weakness in a vertical cast pipe.

"Cold Shuts." The running surface in a vertical cast pipe is so small, that the hot iron falling into it renders the liability to "cold shut" almost an impossibility. The mould and core are of such a na-

ture that if properly made and thoroughly dried, they will stand the passage of a current of iron as nearly perfect as sand moulds can do. There is little or no straining either in mould or core, and this is an important feature, for all strains are a total loss of so much iron that is taken away from other parts of the pipe.

They are cleaner. In casting the pipes the iron is poured into a basin that surmounts the top of the flask and surrounds the core, the runners are in the bottom of this basin, which is instantly poured full, and kept in that state until the pipe is "up," whilst the dirt which gets in this basin (if any) from the ladle, will float there and cannot get into the pipe. Yet there is dirt or impurities constantly giving out from the iron, when in a fluid state, of some manufacturers more than in others; but all gives off more whilst in motion than when at rest; thus all castings will have some dirt in them, however carefully the ladle may be skimmed, because the dirt continues to rise so long as the iron is in a fluid state. In pipes the dirt assumes various forms or positions, depending wholly upon circumstances. In those of large diameters, cast vertically, when the thickness is great, it will collect in lumps and float towards the top, where it is occasionally intercepted and forms a soft place, which will usually "sweat" under pressure, and consequently may be readily found in the press. But in those of small diameters cast in the same manner, so much of the running surface is covered by the runners, and the cast is brought up so quickly, that the dirt has but little time or opportunity to separate from the iron and collect in a body, except in cases where the iron is *very* dirty, when it will rise towards the top, in which case the proof pressure will find it. The dirt here spoken of is that which separates from the iron after it has passed the runners into the mould, and is about the same in quantity in any kind of mould, it depending upon the weight of iron poured and the quality of iron used.

In conclusion, I would remark, that the superiority of the vertical over the horizontally cast pipes, consists principally in the following advantages:

1st. There is no lift to the core, or tendency for it to move from the position it is placed in.

2d. The small running surface.

3d. The rapidity with which the pressure is put upon the iron whilst it is in a fluid state.

4th. The iron falling directly to its place with all the velocity and force of its gravity, thereby thoroughly mixing the hot iron with the whole running surface.

5th. The firmness of the mould.

6th. The facilities for making the casting clean.

7th. The ability to increase the length of the pipes without endangering the perfection of the casting, thereby saving in weight of casting, cost of labor, and material in laying, to which add the saving of lead joints, in itself an item of importance.

In reference to the transverse strength of pipes of small diameter, I herewith submit a tabular description, taken from experiments made at the Warren Foundry, Philipsburgh, New Jersey.

TRIAL A.—CAST VERTICALLY.

Pipe 4 inches inside diameter, $\frac{8}{8}$ths of an inch thick, weighing 201 lbs., 12 feet long; supported at the extreme ends. Weight applied on slings three feet from each end. Points of deflection taken three feet from each end and centre.

Weight in lbs.	Hub End.		Middle.		Spigot End.	
	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.
1000	·25	·25	·31	·31	·25	·25
2000	·12	·37	·25	·56	·18	·43
3000	·31	·68	·37	·93	·25	·68
4000	·32	1·00	·38	1·31	·28	·96
5000	·31	1·31	.50	1·81	.29	1·25
5500	·19	1·50	·25	2·06	·18	1·43
6000	·12	1·62	·19	2·25	·13	1·56
6225	Broke in two places, 5 inches in from points of weight.					

TRIAL B.—CAST VERTICALLY.

Pipe 4 inches in diameter, $\frac{8}{8}$ths of an inch thick, 12 feet long, weighing 202 lbs.; supported at the extreme ends, and weights applied in the centre, suspended by a sling. Points of deflection taken three feet from the ends and centre.

Weight in lbs.	Hub End.		Middle.		Spigot End.	
	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.
1000	·18	·18	·31	·31	·18	·18
1500	·19	·37	·25	·56	·19	·37
2000	·19	·56	·31	·87	·19	·56
2500	·19	·75	·25	1·12	·19	·75
3000	·25	1·00	·31	1·43	·28	1·03
3250	·06	1·06	·19	1·62	·03	1·06
3375	·09	1·15	·06	1·68	·09	1·15
3500	·03	1·18	·13	1·81	·01	1·16
3625	·07	1·25	·06	1·87	·05	1·21
3750	·06	1·31	·13	2·00	·07	1·28
3850	Broke 12 inches from centre, towards the hub.					

TRIAL C.—CAST VERTICALLY.

Pipe 6 inches in diameter, $\frac{8}{8}$ths of an inch thick, 12 feet long, weighing 340 lbs.; supported at the extreme ends, and weights applied on slings placed 3 feet from each end. Points of deflection taken 3 feet from each end and centre.

Weight in lbs.	Hub End.		Middle.		Spigot End.	
	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.
1000	·03	·03	·03	·03	·03	·03
2000	·09	·12	·15	·18	·09	·12
3000	·09	·21	·13	·31	·09	·21
4000	·07	·28	·03	·34	·07	·28
5000	·06	·34	.09	·43	·03	·31
6000	·09	·43	·16	·53	·06	·37
7000	·07	·50	·10	·69	·06	·43
8000	·00	·50	·06	·75	·07	·50
9000	·09	·59	·06	·81	·06	·56
10000	·09	·68	·09	·90	·06	·62
11000	·13	·81	·13	1·03	·10	·72
12000	·03	·84	·15	1·18	·03	·75
12900	Broke at the points of weight.					

TRIAL D.—CAST VERTICALLY.

Pipe 6 inches in diameter, $\frac{8}{16}$ths of an inch thick, 12 feet long, weighing 344 lbs.; supported at the extreme ends, and weight applied on slings at the centre of length. Deflection taken at points three feet from each end and centre.

Weight in lbs.	Hub End.		Middle.		Spigot End.	
	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.	Partial deflection.	Whole deflection.
1000	·12	·12	·12	·12	·06	·06
2000	·06	·18	·19	·31	·12	·18
3000	·13	·31	·06	·37	·07	·25
4000	·06	·37	·13	·50	·06	·31
4500	·06	·43	·09	·59	·06	·37
5000	·03	·46	·06	·65	·06	·43
5500	·10	·56	·10	·75	·07	·50
6000	·06	·62	·06	·81	·06	·56
6500	·06	·68	·12	·93	·06	·62
7000	·07	·75	·13	1·06	·06	·68
7500	·06	·81	·06	1·12	·03	·71
8000	·06	·87	·06	1·18	·04	·75
8500	·06	·93	·03	1·21	·08	·83
9000	·07	1·00	·22	1 43	·07	·90
9115	Broke in the centre.					

TRIAL E.—CAST HORIZONTALLY.

Pipe cast in "green sand," 6 inches in diameter, 9-16ths of an inch thick, 9 feet long, weighing 354 lbs.; supported at the extreme ends, and weight applied on slings in the centre. Deflection taken at centre of length.

Weight in lbs.	Middle.		Weight in lbs.	Middle.	
	Partial deflection.	Whole deflection.		Partial deflection.	Whole deflection.
1000	·03	·03	7000	·03	·28
2000	·03	·06	8000	·06	·34
3000	·06	·12	9000	·04	·38
4000	·03	·15	10000	·02	·40
5000	·07	·22	11000	·13	·53
6000	·03	·25	11700	Broke in the centre.	

TRIAL H.—CAST VERTICALLY.

Pipe 6 inches in diameter, $\frac{8}{16}$ths of an inch thick, 9 feet long, weighing 302 lbs.; supported at the extreme ends, and weight applied at the centre. Deflection taken at same point.

Weight in lbs.	Middle.		Weight in lbs.	Middle.	
	Partial deflection.	Whole deflection.		Partial deflection.	Whole deflection.
1000	·03	·03	8000	·10	·56
2000	·06	·09	9000	·09	·65
3000	·10	·19	10000	·10	·75
4000	·06	·25	11000	·03	·78
5000	·03	·28	12000	·03	·81
6000	·10	·38	13000	·07	·88
7000	·08	·46	13950	Broke in the centre.	

Trials F and G were upon condemned pipes. F broke with a weight of 8400 lbs., and was very defective at the point of rupture. G broke with a weight of 8325 lbs.; the casting was of poor iron and cast with wet core, having caused a boiling surface.

The tensile strength of a pipe 30 inches in diameter, cast at the Florence Foundry, N. J., and afterwards broken up, was tried at the proving machine of the West Point Foundry, and it was found equal to 22,133 lbs. per square inch. This might be considered an average specimen of the iron used in the American foundries for pipe castings.

Specimens taken from pipes cast at the Phœnix Iron Works, Glasgow, Scotland, were sent to the South Boston Foundry, Messrs. Alger & Co., and tried by their proving machine with the following results:

Piece of 30-inch pipe,	.	22,978 lbs.	per sq. in.
" 20-inch "	.	24,222 "	"
" 20-inch "	.	19,493 "	"
" 12-inch "	.	21,290 "	"

For the Journal of the Franklin Institute.

Account of Experiments upon the Advantage of Throttling Steam.

Mr. J. Bermingham, Chief Engineer of the *Golden Age*, made a series of experiments upon that vessel on the 19th of February last, for the purpose of ascertaining the advantage, if any, to be gained by throttling the steam. The vessel is fitted with one vertical beam engine. Diameter of cylinder, 83¼ inches; stroke of piston, 12 feet. The boilers are of the drop-flue kind, two in number, and were made in the year 1852.

The table, as given below, was compiled from six sets of indicator diagrams, taken and worked out with the utmost care.

Engine fitted with Stevens' cut-off.	Cut-off at ¾ of the stroke. Throttle wide open.	Cut-off at ¾ of the stroke. Throttle ½ open.
Pressure of steam in boilers, pounds, .	8·5	15·1
Temperature of sea water, .	86°	86°
Temperature of water discharged from condenser,	115°	114°
Revolutions of wheels per minute, .	11·25	11·14
Indicated horse-power developed by engine,	627·5	610·9
Cubic feet of atmospheric steam used per each horse-power per minute, . .	10·87	10·97
Cubic feet of atmospheric steam used per each revolution of wheel, . .	606·8	601·82
Steam used per each horse-power per hour, pounds,	24·15	24·25
Steam passing the cylinder per hour, pounds,	15055	14787
Coal used per horse-power per hour, pounds, .	3·9	3·9
Water evaporated per pound of coal, pounds,	6·01	6·01
Mean pressure on piston, pounds, .	14·1	13·9
Speed of vessel, miles, . .	9·7	9·657

Temperature of steam entering cylinder, about 275° or 285°
" gases escaping up steam chimney, about 525°
Economy in favor of open throttle, as per results above, $\frac{8}{10}$ths of 1 per cent.

During both trials, the injection valve had exactly the same opening, and it is to be observed that the sea water was precisely of the same temperature.

NOTE.—The dimensions of the *Golden Age* are as follows:—Length on deck, 270 ft. Breadth of beam, 42 ft. Depth of hold, 16 ft. 4 ins. Do., to spar deck, 24 ft. 4 ins. Draft of water at load line, 17 ft. Diameter of water wheels overboards, 34 ft. 6 ins.

E. B.

Cleaning of Platinum.

From the Lond. Chemical News, No. 51.

SIR,—A remarkably rapid and perfect method of cleaning platinum apparatus consists in gently rubbing upon the dirty metal a small lump of sodium-amalgam. Sodium has the curious property of lending to mercury the power of "wetting" platinum in so complete a manner that the positive capillarity between platinum and an amalgam containing even only a few per cent. of sodium appears to be as great as that between mercury and zinc, with this important difference, however,—in the former case the "wetted" metal does not suffer the least trace of amalgamation. Even when foreign metals, such as lead, tin, zinc, silver, are purposely added to the soda-amalgam, the platinum surface suffers no disintegration.

When the amalgam has been rubbed on with a cloth, until the whole surface is brilliantly metallic, water is applied, which oxidizes the sodium and allows the cohesion of mercury to assert itself. On wiping the mercury off, the platinum surface is left in an admirable condition for the burnisher. I suppose the sodium to act here chiefly as a diluent, diminishing thereby the cohesion of the mercury and allowing the adhesion between that metal and the platinum to predominate,—a result which is certainly assisted by the mercury enabling the sodium to offer a clean surface to the platinum, and so allowing the specific adhesion between the two latter metals to be exhibited. F. G.

Laboratory, University of Edinburgh.

Gas-Lighting.

It has been often said that gas-lighting was unknown in the year 1800. Hydrogen gas was used for illuminating in 1733. Clayton's demonstration of gas-lighting by coal gas was before the public in 1737. Dr. Watson produced and burned coal gas in 1767. Murdoch lighted his house at Redruth, Cornwall, with gas, in 1792, and made an extensive gas apparatus at the Soho Works, in 1798, the works being illuminated at the declaration of peace, in 1802. Pall-mall was lighted with gas, made under Windsor's patent in 1804.—*Lond. Engineer, No.* 254.

Saline Strength of the Sea.

From the Lond. Engineer, No. 245.

A new subject of research, which had hitherto been but cursorily touched upon, viz: the amount of salt contained in the sea under different latitudes, has just received a considerable degree of development through the labors of M. R. Thomassy, who, in the pursuit of his object, has crossed the Atlantic several times in all directions, thus performing a voyage of nearly 12,000 leagues. The determination of the degree to which sea water is impregnated with salt in different places is important, both because it exercises an influence over the existence and propagation of various marine species, and because it may furnish mariners with useful indications of certain contingencies worthy of attention. In northern latitudes, for instance, a diminution in the degree of saturation will warn the navigator of the breaking up of ice in the polar regions, or else it will inform him of the proximity of land. For his observations, M. Thomassy has employed the areometer of Beaume, the most convenient instrument of all, since it merely consists of a glass ball with a graduated tube attached to it, which, by sinking more or less in the liquid to be experimented on, denotes its degree of saturation. Assuming this instrument to be so graduated as to denote the liquid it displaces in sinking by thousandth parts to every tenth of a degree, M. Thomassy's experiments show that the salt contained in the water of the Atlantic, taken at the surface, and at a distance from islands, continents, and the ice of the polar regions, is represented by a minimum of 4°, which, under the evaporating influence of the trade winds and a tropical sun, may rise to 4·40°. At the mouths of rivers subject to the tides of the ocean, the areometer, or halometer, as we may call it in the present instance, marks 3° at high tide, the ebb making it fall at least 1° (the more the instrument sinks the less is the salt contained in the water). Along the coasts subject to the influence of rivers, the instrument, according as there is flow or ebb, oscillates between 2·40° and 3·50°, but may rise to 3·80° in southern latitudes. The Gulf Stream marks 3·90. Those who desire further particulars on this interesting subject may consult M. Thomassy's paper in the *Bulletin de la Société Geologique de France*, vol. xvii., p. 666.

On the Impossibility of Puddling Iron which contains Copper.

By Dr. C. List.

From the Lond. Chemical News, No. 68.

It has been stated as a matter of belief among practical iron workers in Germany, that pig iron which contains copper cannot be puddled; assertions having even been made, that when one puddler wishes to annoy another he will sometimes throw a bit of copper—a small coin for example—into the furnace, so that the iron cannot be made to "rise."

Without giving full credence, as yet, to this statement, Dr. List

mentions that he has observed two instances which go to prove that it may be correct. In the case which he has more particularly described, none of the phenomena which ordinarily occur when iron is puddled appeared. Some 400 lbs. of pig iron having been placed in the furnace, were melted in the course of half-an-hour, at which time a sample taken from the molten mass was perfectly white, but the usual evolution of carbonic oxide, and consequent swelling or "rising" up of the mass of scales, &c., about the iron, did not ensue. On the contrary, by the time that the balling together of the iron should have commenced, it was evident that the charge could not be worked off; it was therefore removed from the furnace, after having remained there about three-quarters of an hour. As the melted metal was flowing out it emitted numerous beautiful blue sparks, which were also produced when the metal in the furnace was stirred. The sparks were regarded by the workmen as an indication that the iron contained copper.

The amount of metallic iron which remained weighed 240 lbs., 160 lbs. having been lost in the scales and slag. Analyses (for details of which see the original memoir) were made of the original pig iron, (I.); of the sample taken, as previously mentioned, from the melted iron, as it lay beneath the scales (II.); and of the iron after it had been removed from the furnace (III.)

	I.	II.	III.
Silicon, . . .	1·32	0·29	—
Sulphur, . .	0·28	—	0·20
Manganese, . . .	3·56	—	0·48
Copper, . .	0·35	0·38	0·57

It was evident, therefore, that the 400 lbs. of pig iron used did really contain nearly a pound and a half of copper. It appears, moreover, that copper cannot be removed from iron by puddling. Calculating how much copper ought to be left in the iron which was finally removed from the furnace, in case none had been lost in the slag, it is found that there should be 0·58 per cent., almost exactly the quantity which was obtained in analysis No. III.—*Dingler's Polytechnisches Journal.*

Cæsium.—A New Alkali Metal.

At the last meeting of the Chemical Society, Dr. Roscoe gave a short account of Professors Kirchhoff and Bunsen's spectrum researches, and mentioned that the new alkali metal which they had discovered by that means had been named *Cæsium*, from the Latin word *cæsius*, signifying grayish-blue, that being the tint of the two spectral lines which it shows. By working with the residues from twenty tons of the mineral waters of Kreuznach, Professor Bunsen had succeeded in obtaining about 250 grains of the platinum salt of the new metal. Cæsium is closely allied to potassium in its chemical characters, the chief point of difference being the solubility of its nitrate in alcohol. Its equivalent number is 117,—exactly three times that of potassium. —*Chemical News, No.* 57.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 310.)

Comparative table representing the strength of long flexible pillars of timber and iron to sustain a pressure in the direction of their length, both ends being flat and firmly fixed, and the height of the pillars exceeding 30 times their diameter.

This table shows the calculated breaking weight of solid square pillars of Red Deal and Dantzic oak, seasoned,—uniform hollow cylindrical pillars of cast iron, whose sectional thickness is one inch,—also, uniform solid cylindrical pillars of cast iron and wrought iron.

Length or height of Pillar in feet.	Number of diameters contained in length or height of Pillar.	Diameter or side of Square in inches.	Inter. diam. of Hollow Pillar in ins.	Solid Square Pillar of Red Deal (dry). Calculated break. weight in tons from formula, $w = 7{\cdot}81 \frac{D^4}{L^2}$.	Solid Square Pillar of Dantzic Oak (dry). Calculated break. weight in tons from formula, $w = 10{\cdot}95 \frac{D^4}{L^2}$.	Hollow Cylindrical Pillar of Cast Iron. Calculated breaking weight in tons from formula, $w = 44{\cdot}34 \frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$	Solid Cylindrical Pillar of Cast Iron. Calculated break. weight in tons from formula. $w = 44{\cdot}16 \frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Solid Cylindrical Pillar of Wrought Iron. Calculated break. weight in tons from formula, $w = 133{\cdot}75 \frac{D^{3{\cdot}55}}{L^2}$.
10½	31½	4	2	18·13	25·42	101·99	111·25	166·43
11	33	4	2	16·52	23·16	94·40	102·79	151·64
11½	34½	4	2	15·11	21·19	87·53	95·31	138·74
12	36	4	2	13 88	19·46	81·42	88·66	127·42
12½	37½	4	2	12·78	17·94	75·96	82·71	117·43
13	39	4	2	11·83	16·58	71·06	77·38	108·57
13½	40½	4	2	10·97	15·38	66·64	72·57	100·68
14	42	4	2	10·20	14·30	62·65	68·22	93·61
14½	43½	4	2	9 50	13·33	59 02	64 27	87·27
15	45	4	2	8·88	12·45	55·72	60·67	81·55
13	31 1-5	5	3	28 88	40·49	143·59	170·87	239·74
14	33 3-5	5	3	24·90	34·91	126·59	150·64	206·71
15	36	5	3	21·69	30·41	112·58	133·97	180 07
16	38 2-5	5	3	19·06	27·51	100·88	120·05	158·26
17	40 4-5	5	3	16·89	23·68	91·00	108·29	140·19
18	43 1-5	5	3	15·06	21 12	82 57	98 26	125·05
19	45 3-5	5	3	13 52	18·95	75·32	89·63	112·23
20	48	5	3	12·20	17·10	69 03	82·15	101·29
16	32	6	4	39·53	55 43	175 67	229·32	302 33
17	34	6	4	35 02	49·10	158·46	206·86	267·81
17½	35	6	4	33 05	46·34	150·85	196·92	252·76
18	36	6	4	31·24	43 80	143·79	187·71	238·88
19	38	6	4	28·03	39 31	131·16	171·22	214·39
20	40	6	4	25 31	35·48	120·21	156·93	193·52
18	30 6-7	7	5	57·87	81 14	227·11	324 46	412·89
19	32 4-7	7	5	51·94	72·82	207·16	295 96	370·58
20	34 2-7	7	5	46·87	65·72	189·86	271 24	334·44
22	33	8	6	66·09	92 66	238·08	370·57	444·03
24	36	8	6	55 53	77·86	205·35	319·62	373·11
26	39	8	6	47 32	66 34	179·22	278·96	317·91
28	42	8	6	40·80	57·20	158 01	245·94	274·12
30	45	8	6	35 54	49 83	140 52	218 72	238·79
35	52½	8	6	26·11	36 61	108·12	168·30	175 43
40	60	8	6	19·99	28 03	86·14	134·11	134·32

Tables showing the calculated breaking weight and safe weight of uniform hollow cylindrical pillars of cast iron, and the calculated weight of metal contained in each pillar.

Formula for long flexible pillars of cast iron, their length or height exceeding 30 times their external diameters, both ends of the pillars being flat and firmly fixed:—

$$W = 44{\cdot}34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}.$$

Formula for shorter pillars:—

$$Y = \frac{b\,c}{b + \frac{3}{4}c}.$$

NOTE.—The value of Y in the above formula is compounded of two quantities: b, the strength as obtained from the above formula for long flexible pillars; and c, the crushing force of the material.

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the pillar in lbs.	Calculated breaking weight in tons from formula, $W = 44{\cdot}34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.	Safe weight in tons.
8	32	3	1½	132·32	58·41	14·60
9	36	"	"	148·86	47.81	11·95
10	40	"	"	165·40	39·97	9·99
11	44	"	"	181·94	33·99	8·49
12	48	"	"	198 48	29·31	7·32
13	52	"	"	215·02	25 58	6·39
14	56	"	"	231·56	22·56	5·64
15	60	"	"	248·10	20 06	5·01
16	64	"	"	264·64	17·97	4·49
17	68	"	"	281·18	16·21	4·05
18	72	"	"	297 72	14 71	3·67
19	76	"	"	314·26	13·42	3 35
20	80	"	"	330·81	12 30	3·07
21	84	"	"	347·35	11·32	2·83
22	88	"	"	363 89	10 46	2·61
23	92	"	"	380·43	9·70	2·42
24	96	"	"	396·97	9·02	2·25
25	100	"	"	413·51	8·41	2·10
26	104	"	"	430·05	7 87	1·96
27	108	"	"	446 59	7·38	1·84
28	112	"	"	463·13	6·94	1·73
29	116	"	"	479·67	6·54	1·63
30	120	"	"	496·21	6·17	1·54

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $w = 44{\cdot}31\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $T = \frac{be}{b + \frac{1}{3}c}$.	Safe weight in tons.
8	24	4	2½	191·13		126·95	31·73
9	27	"	"	215·02		110 72	27·68
10	30	"	"	238 91		97·26	24·31
11	33	"	"	262 81	83·75		20·93
12	36	"	"	286 70	72·23		18·05
13	39	"	"	310·59	63 04		15·76
14	42	"	"	331·48	55·58		13 89
15	45	"	"	358·37	49 43		12·35
16	48	"	"	382 26	44·29		11·07
17	51	"	"	406·16	39 95		9 98
18	54	"	"	430·05	36·25		9 06
19	57	"	"	453·94	33·07		8·26
20	60	"	"	477·83	30·31		7 57
21	63	"	"	501·72	27·89		6·97
22	66	"	"	525 62	25·77		6·44
23	69	"	"	549·51	23·90		5·97
24	72	"	"	573·40	22·23		5·55
25	75	"	"	597·29	20 74		5·18
26	78	"	"	621·18	19·40		4 85
27	81	"	"	645·08	18·19		4 54
28	84	"	"	668 97	17·10		4·27
29	87	"	"	692·86	16·11		4·02
30	90	"	"	716·75	15·21		3 80

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $w = 44{\cdot}31\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $T = \frac{be}{b + \frac{1}{3}c}$.	Safe weight in tons.
8	19 1-5	5	3½	249 94		212·52	53·13
9	21 3-5	"	"	281·18		188·80	47 20
10	24	"	"	312 43		168·47	42·14
11	26 2-5	"	"	343·67		151·03	37·75
12	28 4-5	"	"	374·91		136 02	34·00
13	31 1-5	"	"	406 16	123·20		30·80
14	33 3-5	"	"	437·40	108·61		27·15
15	36	"	"	468·64	96·59		24·14
16	38 2-5	"	"	499 89	86·55		21·63
17	40 4-5	"	"	531·13	78 08		19·52
18	43 1-5	"	"	562·37	70·85		17·71
19	45 3-5	"	"	593·62	64·62		16·15
20	48	"	"	624·86	59·23		14·80
21	50 2-5	"	"	656·10	54·51		13·62
22	52 4-5	"	"	687·35	50·37		12·59
23	55 1-5	"	"	718·59	46·70		11·67
24	57 3-5	"	"	749·83	43·40		10·85
25	60	"	"	781·08	40·53		10·13
26	62 2-5	"	"	812·32	37·91		9·47
27	64 4-5	"	"	843·56	35·56		8 89
28	67 1-5	"	"	874·80	33·43		8·35
29	69 3-5	"	"	906·05	31·49		7·87
30	72	"	"	937·29	29·73		7·43

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $w = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{1}{4}c}$.	Safe weight in tons.
8	16	6	4½	308·76		310 91	77 72
9	18	"	"	347 36		280 61	70 15
10	20	"	"	385 96		253·86	63 46
11	22	"	"	424·55		230·32	57·58
12	24	"	"	463·15		209·59	52 39
13	26	"	"	501 74		191·35	47·83
14	28	"	"	540·34		175 20	43 80
15	30	"	"	578·94		161·00	40·25
16	32	"	"	617 53	147·33		36 83
17	34	"	"	656·13	132 90		33 22
18	36	"	"	694 73	120 60		30·15
19	38	"	"	733 32	110·01		27 50
20	40	"	"	771·92	100·82		25 20
21	42	"	"	810 51	92 79		23·19
22	44	"	"	849·11	85·74		21 43
23	46	"	"	887·71	79 50		19·87
24	48	"	"	926·30	73·95		18 48
25	50	"	"	964 90	68·99		17·24
26	52	"	"	1003 49	64 54		16·13
27	54	"	"	1042 09	60 53		15·13
28	56	"	"	1080 69	56 90		14·22
29	58	"	"	1119 28	53·61		13 40
30	60	"	"	1157 88	50·60		12 65

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $w = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{1}{4}c}$.	Safe weight in tons.
8	13 5-7	7	5½	367 56		417·76	104 44
9	15 3-7	"	"	413·51		382·08	95·52
10	17 1-7	"	"	459·45		349·79	87·44
11	18 6-7	"	"	505·40		320·71	80·17
12	20 4-7	"	"	551·35		294·61	73·65
13	22 2-7	"	"	597 29		271·20	67·80
14	24	"	"	643 24		250·23	62·55
15	25 5-7	"	"	689·18		231·42	57·85
16	27 3-7	"	"	735·13		214·52	53·63
17	29 1-7	"	"	781·08		199·31	49·82
18	30 6-7	"	"	827·02		185·61	46·40
19	32 4-7	"	"	872·97	170·93		42·73
20	34 2-7	"	"	918·91	156 65		39 16
21	36	"	"	964 86	144·18		36·04
22	37 6-7	"	"	1010 80	133·22		33·30
23	39 3-7	"	"	1056·75	123 52		30 88
24	41 1-7	"	"	1102 70	114·90		28·72
25	42 6-7	"	"	1148 64	107·20		26·80
26	44 4-7	"	"	1194·59	100·28		25·07
27	46 2-7	"	"	1240 53	94 05		23 51
28	48	"	"	1286·48	88·41		22·10
29	49 5-7	"	"	1332 43	83·29		20·82
30	51 3-7	"	"	1378·37	78·63		19·65

Experiments with the Disc Wheel in Propelling Steamboats.

From the Journal of the Society of Arts, No. 421.

On Tuesday, the 11th inst., an experiment of a novel mode of propulsion in steam navigation was made in a trip from Blackwall to Erith. The paddle wheel and screw have hitherto been the means employed for utilizing steam power in navigation, but Mr. James Jones Aston, of the Middle Temple, has, it appears, taken out a patent for propelling steamships by a very different contrivance. *A priori*, the arrangement invented by Mr. Aston is the very last that would suggest itself to an observer, and the inventor himself candidly admits that both practical men and men of science ridiculed his idea when first propounded. The steam tug *Saucy Jack*—by no means a favorable boat for the success of the experiment—was propelled down the river at a rate of six knots an hour by the agency of a disc wheel, and with a far less expenditure of coal than if either paddles or screw had been used. The earliest objection to the locomotive was that it would not "bite" the rail, but the experiment soon proved the objection to be worthless. It is still more difficult to conceive what hold a thin metal or wooden plate, not striking the water horizontally or obliquely, but cutting into it edgewise, like a knife, can have of the water. The diameter of the disc used in the experiment was 14 feet, with about two feet in the water. The thickness of the plate was only three-eighths of an inch, and it is asserted that the thinner the plate the greater the power. The engines of the tug were 30-inch with a stroke of 42. The greatest number of revolutions made was 47. In the trip down the river the pressure in the boilers was 6 lbs., and coming up 4 lbs., the speed attained being about six knots. With the paddles the tug used to make about eight knots, but the expenditure of fuel was about 40 per cent. in favor of the disc. The conditions under which the trial was made were unfavorable to the experiment. She was not so readily started or so speedily stopped as the ordinary steamboats, but, perhaps, these disadvantages may disappear under more favorable circumstances. The disc may be constructed of metal or wood, or of both in combination, and several discs may be used on the same shaft, at convenient distances apart. There were five plates on each side in this experiment. The advantages of the disc, as enumerated by the inventor, are the following:

1. It is less likely to be disabled in a storm or battle, and is therefore a safer propeller.
2. There are no paddles or blades to agitate the water, and the boat is free from vibration.
3. All the action of the propeller is in the direction in which the boat travels, and the motive power being more perfectly utilized, a much greater rate of speed may be attained than has hitherto been deemed practicable.
4. Its action is perpetual and not intermittent.
5. There is no backwater, or loss of power on that account.
6. It is much less affected by wind and tide.

7. It is the only propeller well suited for canals and shallow rivers.
8. It may be used for small boats and other craft.
9. It may be worked with lower power and at great saving of fuel.
10. It is of more simple construction, less costly, less liable to injury, and causes less wear and tear of the boat.

There were present to witness the experiment:—Capt. Lovell, of the Peninsular and Oriental Company, Mr. Wright, Assistant-engineer-in-chief to the Admiralty, Mr. Adams, Mr. Macrory, and Mr. Aston himself, the inventor and patentee.

On the Strength of Boilers. By J. McF. Gray.

From the Lond. Artizan, Feb., 1861.

Fairbairn's experiments on the strength of boiler plates, of internal flues, of flat surfaces, and of riveted joints, have afforded the engineer precise data on which to base his rules for boiler construction. These experiments are described in "Useful Information for Engineers." In making notes from that work for my private use, I have chosen simple co-efficients for bursting strains, taken away the logarithmic character of the formula for collapsing of flues, and based a general law on the experiments on flat surfaces. The following rules, therefore, yield the same results as the various tables of the above work, and they have been framed so that they could be easily remembered, and the most of them calculated mentally. The law for the strength of flat surfaces is similar to that for the collapsing of tubes; and although it has not been pointed out as a law by Mr. Fairbairn, yet it is to his experiments we are indebted for its practical demonstration. As this law is here published for the first time and may surprise some, I will be more explicit with it than with the others, to show that it is theoretically correct, and that it is also in every respect confirmed by these experiments.

Taking the tensile strength of wrought iron plates at 23 tons per square inch, and the value of a riveted joint at 0·56 of the solid plate, or 28,750 pounds per square inch, Mr. Fairbairn ascribes a tensile strength of 34,000 pounds per square inch to the shell of a cylindrical boiler, as these boilers have the joints arranged to break band with each other. In the following rules for cylindrical shells I have adopted 34,000 as the standard of maximum strength. At the beginning of each rule the degree of approximation to this standard which is attained by using the co-efficients in the rule is indicated by a fractional quantity, in which the numerator is the ultimate strain per inch, and is as near as possible to 34,000. The denominator is the factor of safety for which the rule is constructed. Mr. Fairbairn gives *six* as the factor of safety for new boilers of good construction; this factor is to be taken as a limit to the pressure which a new boiler will bear with safety, and not as a rule for the regular working pressure of the boiler. To allow for deterioration, the bursting pressure of a boiler when new should be at least *eight* times the pressure at which it is intended that the boiler should be used. It is his opinion that "every

description of boiler used in manufactories or on board of steamers should be constructed to a bursting pressure of 400 to 500 lbs. on the square inch; and locomotive engine boilers which are subjected to a much severer duty, to a bursting pressure of 700 to 800 lbs.

At page 43 there is a table for thickness of the plates of a cylindrical boiler in decimal parts of an inch for a bursting pressure of 450 lbs. to the square inch, strain 34,000 lbs. per square inch: on examining the figures it appears to be calculated to a strain of 32,400 —or, otherwise, that the pressure is not 450, but 472. The first of the following rules gives a result corresponding to that table.

Cylindrical Shells—Internal Pressure.

(*Diameter in feet, thickness in inches, pressure in pounds per square inch.*)

1. $\left(\frac{32400}{1}\right)$ The thickness of the shell in inches for a bursting pressure of 450 lbs. per square inch is the diameter in feet divided by 12.

2. $\left(\frac{33600}{8}\right)$ The working pressure is 700 times the thickness divided by the diameter.

3. $\left(\frac{33600}{8}\right)$ The thickness of plates required for a cylindrical boiler is equal to the (product of the diameter by the working pressure) divided by 700.

4. $\left(\frac{33600}{8}\right)$ The greatest diameter of shell with a given thickness of plates and a given working pressure is 700 times the thickness divided by that pressure.

5. $\left(\frac{34000}{8}\right)$ For the working pressure of cylindrical boilers constructed of $\frac{3}{8}$ plates, divide the number 263 by the diameter of the boiler in feet.

6. $\left(\frac{34000}{8}\right)$ For the working pressure of cylindrical boilers constructed of $\frac{1}{2}$-inch plates, divide the number 354 by the diameter in feet.

Collapsing of Internal Flues.

The experiments conducted by Mr. Fairbairn under the sanction of the Royal Society enabled him to establish a formula of strength for internal round flues. That formula is

$$P = 806{,}300 \frac{K^{2\cdot19}}{L\ D}.$$

Where P is the bursting pressure, K the thickness of the plate in inches, L the length of the flue, and D its diameter, both in feet.

This formula cannot be used but with the aid of logarithms, because of the index 2·19. Instead of this I have constructed the following rules:

7. The collapsing pressure of an internal cylindrical flue is 66 times the square of (one less than the number of thirty-seconds of an inch in the thickness of the plate), divided by the (product of the length by the diameter), both in feet.

8. The square root of the (product of the collapsing pressure, by the length, by the diameter, divided by 66) increased by 1, is the thickness of the plate in thirty-seconds of an inch.

The degree of approximation attained by this rule is, it is one-five-hundredth part of an inch below the thickness in the table for a flue 10 feet long, 1 foot diameter; and it is one-fiftieth of an inch above the thickness for a flue 30 feet long, 4 feet diameter, the collapsing pressure being 450 lbs. per square inch in both. The two rules agree when the plates are $\frac{1}{4}$ of an inch thick, also when the plates are $\frac{9}{16}$ of an inch thick; between these, this rule gives thinner plates, the greatest difference being when the plates are about $\frac{3}{8}$ of an inch thick; this rule gives the thickness $\frac{1}{30}$ of an inch less than is found by the logarithmic formula. For all other thicknesses this rule errs in excess of strength, and may thus be used for all plates from $\frac{3}{16}$ of an inch to $\frac{7}{8}$ of an inch thick.

Strength of Flat Stayed Surfaces,

Such as the sides of the fire-box of a locomotive boiler, the stays being screwed into the plate without nuts.

From an examination of the sketch of the boxes experimented on by Mr. Fairbairn, showing the bulging of the plates, it appears that before the box burst, by one of the stays being drawn through the plate, the bulging of the plate was continued close up to that stay *without contrary flexure*, forming a conical surface around the stay. The plate gives way first at the insertion of the stay; at the inner edge of the hole the plate will be in a state of extension, and at the outer edge in a state of compression; and the *ultimate angular deflection* of the surface of the plate around the stay will be the same for equal thickness of plate whatever be the distance between the stays. The ultimate angular deflection at the stay being thus a constant, the ultimate linear deflection midway between the stays will be *simply as the distance of the stays*. If the conditions of the strains were such that the box would burst by the plate's rending at the middle of the bulgings, or midway between the stays, the ultimate pressure would be such that the total load on a square contained by four stays would be the same, whatever the distance of the stays might be. The ultimate linear deflection would then be as the square of the distance of the stays, as in beams of equal depth. In a beam the deflection is proportional to the load. If equal loads would produce deflections proportional to the *square of the distance*, loads which are *inversely as the distance of the stays* would produce deflections proportional to the *distance simply*. But the stay is drawn through the plate when the linear deflections are as the *distance simply*, therefore the ultimate load upon each square will be inversely as the distance between the stays.

The pressure per square inch is the total load per square between four stays, divided by the square of the distance between the stays; therefore the ultimate pressure per square inch will be inversely as the *cube of the distance between the stays*, for equal thickness of plates. For a different thickness of plates the pressure will be proportional to the square of the thickness of the plate.

It may appear from the tables of the progressive swelling of the sides of the boxes that the bulging did not follow this law. I apprehend that the bulging noted in the table with the first experiment is the swelling of the iron plate, not of the copper one. It was the copper plate that failed, and the sketch appears to agree with my reasoning on the subject.

Having now arrived at the form of the law, these experiments will afford us co-efficients, and will enable us to confirm the above principles.

As in the rule for the strength of internal flues I have taken the thickness in thirty-seconds of an inch, I will do the same here.

9. The bursting pressure of stayed flat iron plates is 720 times the (square of the thickness in thirty-seconds of an inch) divided by the (cube of the distance of the stays in inches).

10. The distance from centre to centre of the stays is equal to the cube root of $\left\{\begin{array}{l}\text{(720 times the square of the thickness in thirty-seconds}\\ \text{of an inch) divided by the bursting pressure}\end{array}\right\}$.

11. The thickness of the plates in thirty-seconds of an inch is equal to the square root of $\left\{\begin{array}{l}\text{the product of the (cube of the distance of the}\\ \text{stays) multiplied by the bursting pressure, divided by 720}\end{array}\right\}$.

12. For working pressures use 90 instead of 720. For copper plates use 400 for bursting pressure and 50 for working pressure.

These rules agree thoroughly with the experiments, and, as a corroboration of the principle, we can examine the ratio between the co-efficient for iron and that for copper. These co-efficients are to each other as 100 to 55½. The tensile strength of iron and copper stays were, by an experiment in the same appendix, found to be as 28,760 to 16,265, or as 100 to 56½. It may, however, be fairly objected that relative tensile strength is no criterion of these co-efficients. At page 129 of the above work the strength of wrought iron plates and of copper plates is given both for tension and compression, and the sum of the tension and compression in iron is to their sum in copper as 35 is to 19 or as 100 to 54½.

This rule does not apply when the plates are stiffened by angle irons or washer plates, but it shows the necessity of these when the stays are not as close as this rule would demand.

Round Stays.

The tensile strength of wrought iron is taken at 23 tons, or 51,520 lbs. per square inch. The strain upon the section of each stay ought not to exceed one-eighth of this in fresh water boilers, that is, 6440 lbs. In boilers using salt water the factor of safety should be at least *ten*, or, the strain per square inch should not exceed 5152 lbs. In the following rules the co-efficient 5000 for fresh water gives a strain equal to 6361 lbs. per square inch. The co-efficient 4000, to be used for salt water, gives a strain equal to 5089 lbs. per square inch.

Note.—When the boiler is for salt water, use 4000 instead of 5000 in the following rules:

13. The working pressure per square inch is 5000 times the (square of the diameter of the stay) divided by the (square of the distance of the stays).

14. For every given pressure there is a constant ratio between the distance of the stays and their diameters. That ratio is the square root of (5000 divided by the working pressure per square inch).

15. If the ratio of distance to diameter be given, the pressure is found by dividing the number 5000 by the square of that ratio.

TABLE OF FORMULÆ FOR STRENGTH OF BOILERS.

D = diameter in feet.
L = length in feet.
T = thickness in inches.
t = thickness in thirty-seconds.
d = diameter of stays in inches, at smallest part.

B = bursting pressure in lbs. per square inch.
C = collapsing do. do.
P = working do. do.
S = distance between stays in inches.
R = do. do. in diam. of stay.

		Strain per inch.			
Cylindrical boilers, .		$\frac{32400}{1}$	$B = 450$	$T = \frac{D}{12}$	$D = 12\,T$
do. do. .		$\frac{33600}{8}$	$P = \frac{700\,T}{D}$	$T = \frac{D\,P}{700}$	$D = \frac{700\,T}{P}$
do. do. .		$\frac{34000}{8}$	$P = \frac{263}{D}$	$T = \frac{3}{8}$-inch.	$D = \frac{263}{P}$
do. do. .		$\frac{34000}{8}$	$P = \frac{354}{D}$	$T = \frac{1}{2}$-inch.	$D = \frac{354}{P}$
Internal flues, from 3-16-in. to $\frac{7}{8}$-in. plates, .		$\frac{34000}{1}$	$C = \frac{66\,(t-1)^2}{L\,D}$	$t = 1 + \sqrt{\frac{C\,L\,D}{66}}$	$D = \frac{66\,(t-1)^2}{C\,L}$
Stayed flat surfaces, such as the sides of the fire-box of a locomotive boiler, the stays being screwed into the plates without nuts.	Iron	$\frac{31520}{1}$	$B = \frac{720\,t^2}{S^2}$	$t = \sqrt{\frac{B\,S^2}{720}}$	$S = \sqrt[3]{\frac{720\,t^2}{B}}$
		$\frac{51520}{8}$	$P = \frac{90\,t^2}{S^2}$	$t = \sqrt{\frac{P\,S^2}{90}}$	$S = \sqrt[3]{\frac{90\,t^2}{P}}$
	Copper	$\frac{28622}{1}$	$B = \frac{400\,t^2}{S^2}$	$t = \sqrt{\frac{B\,S^2}{400}}$	$S = \sqrt[3]{\frac{400\,t^2}{B}}$
		$\frac{28622}{8}$	$P = \frac{50\,t^2}{S^2}$	$t = \sqrt{\frac{P\,S^2}{50}}$	$S = \sqrt[3]{\frac{50\,t^2}{B}}$
Round iron stays with fr. water,		$\frac{50928}{8}$	$P = \frac{5000\,d^2}{S^2}$	$d = S\sqrt{\frac{P}{5000}}$	$S = d\sqrt{\frac{5000}{P}}$
do.	do.	$\frac{50928}{8}$	$P = \frac{5000}{R^2}$	$d = \frac{S}{R}$	$R = \sqrt{\frac{5000}{P}}$
do.	with salt water,	$\frac{50928}{10}$	$P = \frac{4000\,d^2}{S^2}$	$d = S\sqrt{\frac{P}{4000}}$	$S = d\sqrt{\frac{4000}{P}}$
do.	do.	$\frac{50928}{10}$	$P = \frac{4000}{R^2}$	$d = \frac{S}{R}$	$R = \sqrt{\frac{4000}{P}}$

The following table gives these ratios, which are the distances between the stays expressed in diameters of the stay. Thus, at 50 lbs. pressure in a fresh water boiler, the distance between the centres of two stays is ten times the diameter of a stay.

Ratio.	Pressure, fresh water, lbs. per sq. in.	Pressure, salt water, lbs. per sq in.	Ratio.	Pressure, fresh water, lbs. per sq. in.	Pressure, salt water, lbs. per sq. in.
4	312	250	11	41	33
5	200	160	12	35	30
6	139	111	13	30	24
7	102	81	14	25½	20
8	78	62	15	22	17
9	61	49	18	15	12½
10	50	40			

16. The diameter of the stay is equal to the distance between the stays divided by the square root of (5000 divided by the working pressure).

17. The distance between the stays is equal to the diameter of the stay multiplied by the square root of (5000 divided by the working pressure).

In the rule for flat surfaces I have assumed that the strength would vary as the square of the thickness of the plate. The experiments referred to do not enable us to test the truth of this, because the plates were of the same thickness in both experiments. In the collapsing of flues the strength increases in a higher ratio than that of the square of the thickness; but again, in experiments on the resistance of wrought iron plates to pressure by a blunt instrument at right angles to the surface it was found that the strengths were simply as the thickness. If this holds good in the case of flat surfaces submitted to steam pressure, the formulæ would be:

$$B = \frac{8666\,t}{s^3}, \text{ for iron plates.}$$

$$B = \frac{6370\,t}{s^3}, \text{ for copper plates.}$$

And here again we have co-efficients which are proportional to the tensile strength of iron and of copper, so that these data do not determine whether the strength is as the thickness, or as the square of the thickness of the plates. For $\frac{3}{8}$-inch iron plates or for $\frac{1}{2}$-inch copper plates, either rule will give the same result.

Experiments on the Strength of Paddle Floats.

From Mitchell's Steam-shipping Journal, No. 79.

The Royal paddle yacht *Victoria and Albert*, on the occasion of conveying the Empress of Austria to Madeira from Antwerp, sustained considerable injury to her paddle floats during the exceedingly violent weather she experienced throughout the trip, particularly on the outward voyage. Since she has been placed in dock at Portsmouth, where her floats have been unshipped and examined, it has become a question whether they could not be made from some more durable material than that which has been hitherto used—English oak. To ascertain this satisfactorily, a series of tests have been tried at Portsmouth during the past few days, and the result appears to be that it will be difficult to supersede English oak with any other material more durable for the purpose. Each float of the yacht's paddle measures 11 feet 6 inches in length by 4 feet 4 inches in width, the wood being 4 inches thick. One of these floats—a spare one—was tested. The others tested comprised two new ones of the same wood—English oak, one of American oak, and one of wrought iron, the latter being plates riveted together with a space between. The mode of testing was by

placing the float with its two ends resting on balks of timber. Across the centre of the float, transversely, ran a bar of iron 4 inches square, from which was suspended the weights for trying the float's resisting powers. The American oak broke at 32 tons. The wood forming this float was of the finest character, and most even grain, and without a knot in any part. One of the new English oak floats broke at 28 tons, and the other at 24 tons. These floats were much weakened by having iron plates on their surface, each containing 9 or 10 bolt holes. The one that broke at 28 tons, had it been without this iron plate and its accompanying bolt holes, would doubtless have stood as great a strain as the American oak. The *Victoria and Albert's* spare float broke at 21 tons, and the wrought iron one broke at 19 tons. Had the last mentioned one stood a favorable test, the galvanic action that must be constantly going on between a vessel's wheel floats composed of iron and the copper on her bottom would prove an insurmountable bar to its adoption.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 8.

(Continued from page 321.)

Results of Experiments on the Transverse Strength and Deflection of Wrought Iron Rails (Barlow).

Rails.	Weight per yard.	Length of bearing.	Depth.	Area.	Weight.	Deflection. For weight.	Deflection. For each ton.
	lbs.	Feet.	Inch.	Inch.	lbs.	Inch.	Inch.
Flanches. 2·25 .	60	2·75	4·5	6·166	2240	·027	—
rib, ·65,	60	2·75	4·5	6·166	4480	·031	·004
	60	2·75	4·5	6·166	17920	·057	·005
" 2·6 × 1·25 ins.	60	2·75	4·5	6·166	26880	·087	·010
rib, ·85, .	75	4·5	5·	7·5	4480	·050	—
	75	4·5	5·	7·5	20160†	·165	·023
" 3·5 × ·6 in.	57	2·75	3·5	5·85	4480	·050	—
rib, ·8,	57	2·75	3·5	5·85	17920†	·152	·039
* Head, 2·25 × 1 in. rib, ·75 .	60	2·75	4·	6·7	4480	·034‡	—
Flanch, 3·5 × ·8 .	60	2·75	4·	6·7	17920	·064	·082
Head, 2·5 × ·6 rib, ·6							
Bottom, 1·25 × ·88	51	3·	4·5	5·55	6720§	·024	—

* Equivalent dimensions.

† Destructive weight.

‡ The deflection between this and a like bar to this, reversed, was, for between 5 and 10 tons weight, as ·0074 and ·0059.

§ Destructive weight 7 tons.

As it is impracticable to give any general rule for the deflection of

bars, beams, &c., of different lengths and sections, and when an experiment cannot be made to obtain the deflection in a particular case, reference must be had to the results of previous experiments upon bars, beams, &c., of a like character to that or those for which the deflection is required.

Thus, in the preceding tables, page 318 to 321, are given the deflections ascertained in very many cases, added to which is given a *value* or *constant* obtained by the formula

$$\frac{l^3 \text{ W}}{16\, b\, d^3\, \text{D}}.$$

l representing the length in feet, D *the deflection, and b and d the breadth and depth in inches.*

In the first and second examples of the table are results of two experiments with a like material, but of differing dimensions.

In order, then, to determine the relative values of the constants, the varying elements of the case must be reduced to an uniform measure.

In the examples referred to, the *Values* or constants are as 187 and 292, their sections ($b\, d^3$) as 12 and 16, the weights applied as 120 and 420, and the lengths as 3^3 and 4^3.

If the deflections were in conformance with the formula, the *Values* here deduced would be equal, instead of 187 and 292, the proportion of which is obtained by $\frac{187}{292} = \cdot 64$ of the deflection given by the formula. The deflection as furnished by the table for the second experiment is ·36; *hence*, as ·64 : 1 : : ·36 : ·56 = the calculated deflection of it.

When it is required to estimate the deflection for differing weights, lengths, and sections, and contrariwise, to estimate the weights, lengths, and sections for a given deflection.

Divide the deflections by the cubes of the lengths and by the weights. Or, multiply the deflections by the sections ($b\, d^3$). Thus, if the deflections are as ·15 and 1·20 inches, the weights as 125 and 250 lbs., the lengths as 1 and 2 feet, and the sections as 1×2^3 and 2×2^3 inches.

$\frac{\cdot 15}{1 \cdot 20} \div \frac{1^3}{2^3} = \frac{\cdot 15}{\cdot 15} =$ *quotient of the deflections ÷ the cubes of the lengths, which, being equal, shows the deflections to be as the cubes of the lengths.*

$\frac{\cdot 15}{\cdot 15} \div \frac{125}{250} = \frac{\cdot 0012}{\cdot 0006} = \frac{2}{1} =$ *quotient of the reduced deflection ÷ the weights; hence, the deflections are but one-half of that due to the weights.*

$\frac{2}{1} \times \frac{1 \times 2^3}{2 \times 2^3} = \frac{16}{16} = \frac{1}{1} =$ *product of the preceding quotient and the sections ($b\, d^3$); hence, the reduced deflections to be as the sections.*

Table of the Relative Elasticity of Various Materials (Trumbull).

Cast iron,	1·	Oak,	2·8
Wrought iron,	·86	Pine, white	2·4
Ash,	2·6	" yellow,	2·6
Beech,	2·1	" pitch,	2·9
Elm,	2·9		

General Deductions.

In cast iron the permanent deflection is from one-third to one-fourth of its breaking weight, and the deflection should never exceed one-third of the ultimate deflection.

All rectangular bars of wrought iron, having the same bearing length and loaded in their centre to the full extent of their elastic power, will be so deflected that their deflection being multiplied by their depth, the product will be a constant quantity, whatever may be their breadth or other dimensions, provided their lengths are the same.

The heaviest running weight that a bridge is subjected to is that of a locomotive and tender, which is equal to 1·5 tons per lineal foot.

Girders should not be deflected to exceed the 40th of an inch to a foot in length.

In cast iron the $\frac{1}{20}$th to $\frac{1}{30}$th of the breaking weight will give a visible set.

When a load on a girder is supported by the bottom flanch of it alone it produces a torsional strain.

A continuous weight, equal to that a beam, &c., is suited to sustain, will not cause the deflection of it to increase, unless it is subjected to considerable changes of temperature.

The heaviest load on a railway girder should not exceed $\frac{1}{3}$th of that of the breaking weight of the girder when laid on at rest.

Deflection Consequent upon Velocity of the Load.—Deflection is very much increased by instantaneous loading; by some authorities it is estimated to be doubled.

The momentum of a railway train in deflecting girders, &c., is greater than the effect from the dead weight of it, and the deflection increases with the velocity.

Experiments made by the Commissioners of Railway Structures of 1849, showed that a passing load produced a greater effect on a beam than a load at rest.

A carriage was moved at a velocity of 10 miles per hour; the deflection was ·8 inch, and when at a velocity of 30 miles the deflection was 1·5 inches.

In this case 4150 lbs. would have been the breaking weight of the bars, if applied in their middle, but 1778 lbs. would have broken them if passed over them with a velocity of 30 miles per hour.

Cast iron will bend to one-third of its ultimate deflection with less than one-third of its breaking weight if it is laid on gradually, and but one-sixth if laid on rapidly.

When motion is given to the load on a beam, &c., the point of greatest deflection does not remain in the centre of the beam, &c., as beams

broken by a traveling load are always fractured at points beyond their centres and often into several pieces.

Chilled bars of cast iron deflect more readily than unchilled.

Mean Results of Experiments on the Deflection of a pair of Bars by the Transit of a Load at Different Velocities. (Rep. Comms. on Railway Structures.)

CAST IRON.

LENGTH BETWEEN THE SUPPORTS 9 FEET.

VELOCITY.	Depth.	Breadth.	Weight of load.	Deflection.	Set.	Breaking weight.
	Inch.	Inch.	lbs.	Inch.	Inch.	lbs.
At rest, . .	2·	1	1120	·87	·24	
			2242	4·41	1·43	2256
	3·	1	1120	·35	·08	4235
15 feet per second,	2·	1	1120	1·39	·21	1842
	3·	1	1120	·38	·07	3400
24 " "	2·	1	1120	1·48	·15	1520
			1496	3·94	1·07	1524
29 " "	2·	1	1120	2·28	·20	1216
33 " "	2·	1	1120	2·32	·56	1213
36 " "	2·	1	1120	2·31	·21	1176
43 " "	3·	1	1120	·45	·05	2182
LENGTH BETWEEN THE SUPPORTS 13 FEET 6 INCHES.						
At rest, . .	3·	1	1120	1·35	·20	3124
43 feet per second,	3·	1	1120	2·08	·26	1516
WROUGHT IRON.						
LENGTH BETWEEN THE SUPPORTS 9 FEET.						
At rest, . .	3·	1	1120	·15	—	—
	3·	1	1778	·31	—	—
15 feet per second,	3·	1	1778	·38	—	—
29 " "	3·	1	1778	·50	—	—
36 " "	3·	1	1778	·62	—	—
43 " "	3·	1	1778	·46	—	—
STEEL.						
LENGTH BETWEEN THE SUPPORTS 2 FEET 3 INCHES.						
At rest, . .	·25	2	1120	·70	—	—
15 feet per second,	·25	2	1120	1·02	—	—
29 " "	·25	2	1120	1·46	—	—

Mean Results of Experiments to Ascertain the Deflections of Bars, Beams, &c., when the Load is suddenly applied, but without Impact. (Rep. Comms. on Railway Structures.)

CAST IRON.

LENGTH BETWEEN THE SUPPORTS 9 FEET.

Depth.	Breadth.	Weight.	Deflection and set. Load applied.				Breaking weight.
			Gently.		Suddenly.		
Inch.	Inch.	lbs.	Inch.	Inch.	Inch.	Inch.	lbs.
2·	1	448	1·24	·19	2·05	·43	602
3·	1	784	·59	·06	1·08	·13	1231
1·5	4	784	1·28	·10	2·26	·24	1053

Results of Experiments on the Subjection of Iron Bars to Continual Strains (Rep. Comms. on Railway Structures).

Cast iron bars subjected to a regular depression, equal to the deflection due to a load of one-third of their statical breaking weight, bore 10,000 successive depressions, and when broken by statical weight gave

as great a resistance as like bars subjected to a like deflection by statical weight.

Of two bars subjected to a deflection equal to that carried by half of their statical breaking weight, one broke with 28,602 depressions, and the other bore 30,000 and did not appear weakened to resist statical pressure.

Of a number of bars subjected to a vibratory depression, equal to the deflection due to a load of one-third of their statical breaking weight, one broke at 51,538 depressions, and one bore 100,000 without any apparent diminution of resistance.

Of three bars subjected to a like character of depression, equal to the deflection due to a load of one-half of their statical breaking weight, they broke at 490,617, and 900 depressions respectively.

Hence, cast iron bars will not bear the continual applications of one-third of their breaking weight.

A bar of wrought iron, 2 inches square and 9 feet in length between its supports, was subjected to 100,000 vibratory depressions, each equal to the deflection due to a load of five-ninths of that which permanently injured a similar bar, and their depressions only produced a permanent set of ·015 inch.

Three wrought iron bars were subjected to 10,000 vibratory depressions, depressing them through one-third, two-thirds, and five-sixths of an inch respectively, without receiving any perceptible permanent set.

A bar of wrought iron depressed through one inch received a set of ·06 inch, and one depressed 300 times through two inches received a set of 1·08 inch.

The greatest deflection which did not produce any permanent set was due to rather more than one-half the statical weight, which permanently injured it.

A wrought iron box girder, 6 × 6 inches and 9 feet in length, was subjected to vibratory depressions, and a strain corresponding to 3752 lbs. repeated 43,370 times, did not produce any appreciable effect on the rivets.

Room for Improvement in the Steam Engine.

From the London Engineer, No. 252.

The unit of heat is that which is sufficient to raise the temperature of one pound of water by 1 deg. of Fah. The unit of work is the raising of one pound weight through a vertical height of one foot—called a foot pound. The experiments of Mr. Joule, of Manchester, indicated that if the whole of the heat could be rendered available, a unit of heat would raise 772 pounds 1 ft. high; in other words, a unit of heat is equal to 772 foot-pounds. This is called Joule's equivalent. A pound of charcoal will raise 78·15 pounds of water 180 deg., which is equal to 14,067 units of heat. This multiplied by 772, gives 10,859,724 foot-pounds, which is equal to the production of 5½ horse power from the combustion of 1 lb. of charcoal per hour. As the best engines consume nearly 2 lbs. of coal per horse power per hour, it follows that about only one-tenth part of the gross power of the fuel is utilized.

On the Resistance offered by Cast Iron to Internal Pressure. By Mr. John Briggs.

From Newton's London Journal, March, 1861.

The author commenced by stating that he considered cast iron to be the most deceptive of all metals, for in addition to its liability to unsoundness in the process of casting, and fracture from unequal expansion, it was affected injuriously from a variety of other causes. Pig iron was iron in its most impure state, for it was contaminated by all the impurities which were capable of combining with it in its primitive form as ore, and which chemical affinity prevented its parting with in the process of smelting. Frequently, indeed, it was found that the same charge yielded iron of totally different qualities. It had occurred to the reader of the paper that some of the impurities which thus interfered with the character of cast iron were actually other metals, and modern chemistry supported the theory. Many mineral productions, which were formerly considered simple substances, had been proved to have metallic bases, from which had been obtained metals; for example—aluminium, barium, magnesium, calcium, and silicium. Then again manganese, which abounded in the Bowling and Low Moor irons, and which gave them their superiority for solidity and strength, and caused them to be largely used in the manufacture of heavy guns, might be mentioned. There were several other elements, such as carbon, sulpur and phosphorus, which more or less affected the character of cast iron. The first named gave fluidity and softness to the iron, while sulphur and phosphorus were the greatest enemies it had to contend against.

These were the primary points which those who employed cast iron in the construction of cylinders intended to resist great internal pressure—whether in the shape of pieces of ordnance or of hydraulic presses—had to deal with, and perhaps no one had labored more zealously to comprehend and explain them than had one of their own members—Mr. Keyte, when employed at Woolwich Arsenal The existence of the various substances and elements he (Mr. Briggs) had named, was doubtless due to the peculiarities of the localities in which the ore was obtained. In addition, however, he must be permitted to say, that the constitution of cast iron was materially affected by the manner of smelting it. It was necessary to exercise great care in this operation, and in making proper selections of different kinds of iron for particular purposes. The judgment of the iron founder must be largely relied on in this case; and it was well when that judgment was not at fault. Without detaining the meeting further, he should now reiterate the assertion, that cast iron was the most deceptive of all metals, and required to be dealt with accordingly. Mr. Briggs next referred more directly to the subject of his paper. There was a limit to the pressure which should be put internally to cast iron, and there was, he was bold to assert, a limit also to the *thickness* of metal to be used for cylinders of hydraulic presses. Such a statement might at the first blush, appear to be irrational. The general opinion would

undoubtedly be, that the thicker the iron, the greater its resistance to pressure where the bore remained the same size. This he believed not to be the case, and Mr. Joseph Bramah had long ago the same opinion. At the time that one of the press cylinders employed in raising the tubes of the Britannia-bridge had burst asunder, a workman, once in the employment of Messrs. Bramah, thus wrote to the *Mechanics' Magazine* (Sep. 29th, 1849): "At Bramah's we never found presses in constant work stand more than three tons (6720 lbs.) on the square inch, and the greatest pains were taken to obtain the most approved kinds of iron—mixed qualities—to cast cylinders from. I have seen press cylinders stand 7000 lbs. and even 8000 lbs. on the square inch under proof for a short time; but we never could trust them to work with so much, and cast iron then was far superior to that of the present day. Increasing the thickness of the metal in press cylinders was seldom successful. I have known metal 7 inches thick stand as well as that of 10½ inches, for presses with rams 10 inches diameter. The thicker the metal, the greater appeared to be the difficulty in getting it equal and homogeneous throughout." The writer of the foregoing had assisted in the construction of upwards of 100 hydraulic presses at Bramah's, and his remarks came with all the weight, therefore, of authority based on experience. For himself he must say that his own experience, though more limited in extent, confirmed him in a like opinion. He, indeed, almost thought that the error at present consisted in making such cylinders too thick. If the metal were used thinner, there would be more certainty of obtaining castings of greater density and uniformity, and therefore, better calculated to sustain pressure. Mr. Briggs next adduced some instances of fractured cylinders, and referred to a list which he had, in a former paper, laid before the meeting. Experiment and experience, then, alike induced him to believe that there should be a limit to the thickness of all cylinders intended to resist high pressures.

Some examples touching the maximum of pressure to be employed were adverted to, and much information, of a practical nature, was given in relation to this part of the subject. The general conclusions arrived at by the author were as follows:—Three tons per circular inch he considered to be the bursting pressure of press cylinders. The maximum thickness of metal, when all due care had been exercised in its composition, should not be more than the radius of the bore of the cylinder. Two tons per circular inch was a safe pressure to work up to, and this he should pronounce to be his own standard. With these deductions, and with the announcement that at the next monthly meeting he would pursue the questions as to how the pressure is distributed, the commencement of fracture, the line of fracture, the direction of the forces within the cylinders, and introduce the opinions of the late Mr. Robert Stephenson, the author concluded his remarks.

During the discussion, which followed the reading of the paper, Mr. Ives (of Messrs. Grissel's) observed, that one important point in the manufacture of cylinders was the question as to whether the metal of which they were made should be hard or soft.

Mr. James Robertson (of Bankside) said the whole matter was one of great interest. The mysteries of cast iron were not yet revealed, and good iron sometimes became worthless from causes apparently inexplicable. Mechanical and chemical tests were frequently contradictory in relation to cast iron. He had a notion that despite the expense, wrought would be found the most fitting material for press cylinders. Still it was a debatable point.

Mr. Sanson agreed with Mr. Robertson as to the advisability of trying wrought iron. Many failures occurred in the casting of cylinders such as those under discussion, and the expense thus was much increased. Wrought iron guns had been proved far superior in all respects to cast; why not make hydraulic press cylinders of the same substance?

Mr. Davis agreed that cast cylinders might be made too thick, and in such case porosity was the enemy to be feared.

Mr. Keyte considered that it was an important assertion that thickness of metal did not increase strength, and one likely to lead to diversity of opinion indoors and out.

Mr. Aydon believed that cast steel was the best material after all for press cylinders. He should not hesitate to employ a pressure of ten tons to an inch in such a case.

Mr. Oubridge (of Messrs. Simpson's) said, the two main objects to be regarded were the proper mixture of the iron and the thickness of metal. With regard to the first, Mr. Ellis, one of their own members, and now with Watt and Company at Soho, had made many useful experiments, and he found that the quality of iron depended much on the fuel used in smelting it. That which was most free from sulphur was undoubtedly best.

Other members joined in the discussion, and after passing a vote of thanks to Mr. Briggs, the meeting reverted to another subject. This was a consideration of Mr. Ramsell's patent boiler plates, with undulating surfaces and plain edges. The nature of the invention was explained by Mr. Robertson with the aid of a model plate which he exhibited.—*Proceedings Association Foremen Engineers.*

Improvements in the Manufacture of Thin Sheet Lead Coated with Tin.—Specification of the Patent granted to GEORGE TOSCO PEPPE. Dated March 22, 1860.

From the Repertory of Patent Inventions, Dec., 1860.

The thin sheets of lead herein referred to, are obtained by cutting from the outer surface of a mass or cylinder of lead, and I propose to utilize the fresh unoxidized surface of the thin sheet of lead so obtained, to deposit thereon a continuous, unbroken, and adherent coating of metallic tin, by means of the electro-plating process.

The electro-plating of lead has been attempted before, but has not been commercially successful, on account of the expense of cleaning the surface of other than thick sheets of lead, and the difficulty of obtaining by the electro-chemical process a proportionate thickness of

reguline or metallic tin to admit of profitable lamination with the lead by means of rollers.

The cleaning of thin sheets of lead by other than the cutting process, and upon which an adequate thickness of reguline tin can be deposited by electro-chemical means, so as to admit of lamination, being impracticable on account of the expense, I take advantage of the freshly cut unoxidized surface, which is incidentally obtained in the cutting process, to deposit on it a proportionate thickness of tin to bear lamination by rolling.

I take the thin sheet lead as it comes in a continuous sheet from the cutting machine and conduct it into a trough containing, by preference, stannate of soda, but other solutions may be used, such as the stannate of potash, or a solution of cyanide of potassium and tin. These solutions are maintained at a temperature varying from 150 degrees to 170 degrees of Fahrenheit, either by means of a gas stove underneath an earthenware trough, or by the injection of steam into a wooden trough. The depositing trough must not be made of any metal capable of having tin deposited upon it. The thin sheet lead is conducted along the bottom of the trough on a series of wooden rollers revolving freely on axes within the trough. The thickness of the coating of tin will depend upon the length of the depositing trough, and the speed with which it is passed along it, and also upon the intensity of the battery power employed, when the period during which the lead remains in the trough is limited. In the depositing trough, I suspend over the sheet lead a plate of metallic tin of the same dimensions as the immersed portion of the lead. This tin anode is connected with the positive pole of the battery or batteries employed, while the negative pole is connected with the sheet of lead either through the cutting machine or through the medium of the metallic rollers which receive the sheet lead as it emerges from the bath. The tin anode is kept from coming in contact with the sheet lead by means of wooden or glass supports, which can be elevated or depressed at pleasure, so as to regulate the distance between the lead and tin. I prefer to suspend the tin anode directly over the lead cathode, but it may be placed vertically when the lead is in the same position alongside it.

In cases where it is desired to plate the lead with a thicker coating of tin than can be deposited upon it during the time it is passing through the trough in connexion with the cutting machine, I first allow the lead to pass through the trough in order to prevent the surface from oxidation by the deposition of a thin coating of tin as before described. I cut the sheet lead as it comes from the machine into pieces of a convenient size, and immediately immerse them in thin solutions in suitable depositing troughs, having no connexion with the cutting machine, and having a tin anode, as before described, connected with the positive pole of the battery or batteries employed, while the lead is connected with the negative pole.

By increasing the intensity of the current of electricity while the quantity remains the same, the rapidity of deposition, and the thick-

ness of the tin coating, may be regulated with facility, and other means usually employed by electrotypists. When a sufficient thickness of the tin coating has been obtained, the lead is to be passed between laminating rollers until it is drawn out to the thinness required. By this means, the surface of the tin deposit is rendered bright and smooth. If required, the laminated lead may be again put into the depositing trough to receive a fresh coating of tin, and again extended and smoothed by passing between the rollers, and the same process may be repeated, so as to give any required degree of thickness to the tin coating. The lead so coated may be used as a material for wrapping up articles which are injuriously acted upon by lead, or it may be formed into capsules or covers for closing the mouths of bottles and other vessels.

Having described the nature of my invention and how it is to be performed, I do not claim the cutting of thin sheets of lead from a revolving cylinder, nor do I claim the deposition of tin on surfaces of lead prepared by other than the cutting process; what I do claim is, the utilization of the fresh and clean surface incidentally produced by the cutting process, to apply thereto a continuous, unbroken, and adherent coating of metallic tin, of sufficient thickness in proportion to the lead to admit of lamination, or rolling into thin leaves, without exposing the lead surface.

New Zealand Steel.

From the Lond. Mechanics' Magazine, Dec., 1860.

Ever since the settlement of New Zealand by Europeans, their attention has been daily called to the peculiarities of a kind of metallic sand along the shores of New Plymouth, in Taranaki. This sand has the appearance of fine steel filings, and if a magnet be dropped upon it, and taken up again, the instrument will be found thickly coated with the iron granules. Our attention was recently drawn to this singular substance by a friend, and the *Australian Mail* now gives a lengthy account of it. It states that the place where the sand abounds is along the base of Mount Egmont, an extinct volcano, and the deposit extends several miles along the coast, to the depth of many feet, and having a corresponding breadth. The geological supposition is, that this granulated metal has been thrown out of the volcano, along the base of which it rests, into the sea, and there pulverized. The quantity is so large, that people out there looked upon it as utterly valueless. Captain Morshead, a gentleman in the West of England, was so much impressed with its value, that he went to New Zealand to verify the reports made to him in this country, and was fortunate enough to find them all correct. He smelted the ore first in a crucible, and subsequently in a furnace; the results were so satisfactory, that he immediately obtained the necessary grant of the sand from the government, and returned to England with several tons for more conclusive experiments. It has been carefully analyzed in this country by several well-known metallurgists, and has been pronounced to be

the purest ore at present known; it contains 88·45 of peroxide of iron, 11·43 of oxide of titanium, with silica, and only ·12 of waste in 100 parts. Taking the sand as it lies on the beach and smelting it, the produce is 61 per cent. of iron of the very finest quality; and, again, if this sand be subjected to the cementation process, the result is a tough, first-class steel, which, in its properties, seems to surpass any other description of that metal at present known. The investigations of metallurgical science have found that, if titanium is mixed with iron, the character of the steel is materially improved; but, titanium being a scarce ore, such a mixture is too expensive for ordinary purposes. Here, however, nature has stepped in, and made free gift of both metals on the largest scale. To give some idea of the fineness of this beautiful sand, it will be enough to say that it passes readily through a gauze sieve of 4900 holes or interstices to the square inch. As soon as it was turned into steel, by Mr. Mushet of Coleford, Messrs. Moseley, the eminent cutlers and toolmakers, of New street, Covent Garden, were requested to see what could be done with the Taranaki steel. They have tested it in every possible way, and have tried its temper to the utmost, and they say the manner in which the metal has passed through their trials, goes far beyond any thing that they ever worked in steel before. Messrs. Moseley, in whose hands the sole manufacture of cutlery and edge-tools is vested for this country, have placed a case filled with the metal in all its stages, in the Polytechnic Institution. There is the fine metallic sand, some beautiful specimens of the cutlery made from it, and the intermediate phases of the iron and steel. An official experiment is expected to be made at some of the government establishments shortly, and it is also intended to forge some chain-cables, anchors, &c., in order to fully set forth the great superiority of the Taranaki iron.

The Patent Type-founding vs. Richard and another.

From the Lond. Mechanics' Magazine, March, 1861.

This was an action to recover damages upon the ground that the defendants had infringed a patent for an improved manufacture of type.

Mr. Lush, Mr. Hindmarsh, and Mr. Gates appeared for the plaintiffs; and Mr. Knowles, Mr. Grove, and Mr. Webster for the defendants.

It was stated by the plaintiff's counsel, that the patent in question was taken out in 1854 by Mr. Johnson, and this patent was now vested in the plaintiffs. The defendants, Messrs. Miller and Richard, were extensive type-founders in Edinburgh. Before Mr. Johnson's patent, type was made out of a combination of lead and antimony, there being about 75 per cent. of lead. Various attempts had been made to harden type metal, some persons using copper and others zinc; and in the Exhibition of 1851, there was shown a French invention for making type out of copper wire by pressure, without fusion. It turned out, however, that copper would not stand washing, and the invention,

therefore, became useless. Mr. Johnson had been engaged since 1849 in inquiring into the matter, and he was aware that a small proportion of tin had been put into type metal to make it "tougher," but nobody had used it to "harden" the metal. It could not be accounted for chemically that a larger proportion of a soft metal should make the compound harder; but Mr. Johnson found that by using a large proportion of tin he could make a metal that would fuse readily, cool quickly, and come out so hard that you could use the metal as a punch when applied to the ordinary type metal. Mr. Johnson accordingly took out a patent, in which he said that he claimed every combination of the three metals which contained 25 per cent. of antimony and 75 per cent. of tin and lead, of which the minimum of tin must be 25. The defendants, in their circular issued in January, 1856, stated that they had during the last ten months been augmenting the strength of their metal, and this enabled them with confidence to offer a quality of type surpassing every other; and they sold type to the *Times* and other establishments. This type, the plaintiffs contended, had been made in violation of their patent rights, the type having in it more than 25 per cent. of tin.

The defence was, that it had been long known that tin possessed the quality of hardening the metal, and it had been used in combination for making ship nails, which were so hard that they would penetrate oak without being blunted. In Savage's "Dictionary of the Art of Printing," published before the patent, there was a description of tin, lead, and antimony being used for type metal, very much in the proportions given in Mr. Johnson's patent; and in a treatise on "English Founding and Foundries," published in 1778, a mixture of tin and lead was described as being less flexible and more solid and durable than lead. The "French Encyclopædia" also said that a great quantity of tin was used in combination with lead and antimony. Beyond this, the defendants had for many years used tin; and the principle of the use of tin, as provided for by Mr. Johnson's specification, was not new, and therefore his patent was not a valid one.

A great deal of evidence on both sides was laid before the jury, and in the course of the evidence for the defendants the jury stopped the case, and a non-suit was entered.

On Rifled Cannon. By Capt. BLAKELEY.

From the Lond. Athenæum, July, 1860.

The writer pointed out that to make an efficient rifled gun, no more was needed than to copy any good small rifle in the number and shape of the grooves, degree of twist, and other details, provided one difficulty was overcome, viz: that of making the barrel strong enough. Taking Sir W. Armstrong's 80-pounder as a standard, Capt. Blakeley gave several examples of large rifled cannon on the model of successful small ones, which had given satisfactory results in every way, except that they had failed after a short time for want of strength. Mr. J. Lawrence, in 1855, rifled a 6½-inch gun with three shallow broad

grooves, like an Enfield, and fired a lead and zinc bullet, like the Enfield. At an elevation of 5°, the range was 2600 yards—150 more than Sir W. Armstrong's; but the gun burst after about 50 rounds. Mr. Whitworth, after making some excellent small arms and nine-pounders, tried a large gun with 4 inches bore, and sides 9 inches thick; but it burst. He then tried another, 11 inches thick, and it, too, burst. He had, however, since made a stronger cannon, whose success was absolute proof that the one thing wanting in the other was strength. Capt. Blakeley explained his own method of obtaining strength, which consists simply of building up the gun in concentric tubes, each compressing that within it. By this means the strain is diffused throughout the whole thickness of the metal, and the inside is not unduly strained, as in a hollow cylinder made in one piece. As the whole efficacy of the system depended entirely on the careful adjustment of the size of the layers, Capt. Blakeley said he was not astonished that Sir W. Armstrong had lately failed utterly in his attempts to carry it out, because he did not put on the outer layers and rings with any calculated degree of tension; "they were simply applied with a sufficient difference of diameter to secure effectual shrinkage," to quote his own words at the Institution of Civil Engineers. To show that the late failure by Sir W. Armstrong did not disprove his, Capt. Blakeley's, theory, he quoted official reports of a trial of a nine-pounder made by himself in 1855, which showed an endurance sevenfold that of an iron service gun, and threefold that of a brass gun, as well as of an 8-inch gun, from which bolts weighing 4 cwt. had been fired, and of a 10-inch gun, which had discharged bolts weighing 526 lbs. Mr. Whitworth's last new 80-pounder was another instance of the successful application of Capt. Blakeley's principle. To quote Mr. Whitworth's own words,—"It was made of homogeneous iron. Upon a tube having an external taper of about one inch, a series of hoops, each about 20 inches long, were forced by hydraulic pressure. Experiments had enabled him to determine accurately what amount of pressure each hoop would bear. All the hoops were put on with the greatest amount of pressure they would withstand without being injured. A second series was forced over those first fixed." This gun was so made at Capt. Blakeley's suggestion. The method of rifling adopted by Capt. Blakeley cannot be made intelligible without a diagram; but it may be described as a series of grooves of very shallow depth, so arranged as to exert a maximum force in the direction of the rotation of the bullet with a minimum force in a radial or bursting direction. Capt. Blakeley exhibited in the court of the building in which the Section met, a 56-pounder constructed on his own plans, from which he had thrown shells on Mr. Bashley Britton's system to a distance of 2760 yards, with only 5° of elevation, which was stated to be a range 200 yards greater than that of Sir W. Armstrong's 80-pounder.

Dr. SCOFFERN said, he thought Capt. Blakeley had proved his point, that strength was the important desideratum. He said that a large number of Sir W. Armstrong's large guns had lately burst.

Mr. E. COWPER agreed with Capt. Blakeley. Sir W. Armstrong's guns that were said to have burst, were simply cast iron guns hooped. For small arms, he was of opinion that the Lancaster rifle was very successful. The bullet was of lead, and did not jam, as was sometimes the case with the iron shot in the larger guns. If Capt. Blakeley's plan were adopted, he thought that for £10 any gun in the service might be made sufficiently strong.

Mr. DENNIS thought that Capt. Blakeley's method of giving strength was right.—*Proc. Brit. Assoc. for Advance. of Sci.*

Firing Gunpowder by Electricity.

From the London Athenæum, March, 1861.

An important Report has been presented to the Secretary of State for War on the results of elaborate investigations and experiments made at Woolwich and Chatham by a committee on the application of electricity from different sources to the explosion of gunpowder. The report is drawn up by Professor Wheatstone and Mr. Abel, Chemist to the War Department. The following are the conclusions arrived at:—

1st. The explosion of a single charge of powder by means of the phosphide of copper fuse and a magneto-electric apparatus (even of the smallest size generally manufactured) is absolutely certain.

2d. The phosphide of copper fuse is as safe and permanent as any arrangement employed in the service for the ignition of gunpowder by the aid of friction or percussion.

3d. With the employment of a magneto-electric apparatus similar to that used in the Chatham experiments, and termed by Mr. Wheatstone, the "Magnetic Exploder," the ignition at one time of fuses, varying in number from 2 to 25, is certain, provided these fuses are arranged in the branches of a divided circuit in the manner described. To attain this result it is only necessary to employ a single wire, insulated by a coating of gutta-percha or india-rubber, and simple metallic connexions of the apparatus and the charge with the earth.

4th. The explosion of from 12 to 25 charges may be effected in the above manner, at a distance of at least 600 yards from the apparatus, with a rapidity which in its results will in all probability have the practical effect of a simultaneous discharge. This statement, however, only refers to charges on land.

5th. The number of submarine charges which can be exploded with certainty at one time by means of the magnetic exploder is more limited; but if such charges are entirely or partially imbedded in sand, mud, or other dense materials, from two to ten may be fired with certainty. If the charges are suspended in, or are immediately in contact with water, only four can be exploded at one time with certainty. By the employment of separate wires leading from the instrument to each charge, there is little doubt, however, that the results obtained with the magnetic exploder in submarine operations would be quite equal to those definitely established for the ignition of charges on land.

6th. The only important precautions to which it is necessary to attend rigidly, in order to insure uniform success in the application of the magnet, are the proper insulation, throughout, of the main wire and branch wires leading from the instrument to the charges, and the thorough protection of all connexions of wires from the access of moisture.

7th. The system of firing charges by magneto-electricity thus possesses important advantages over the application of the voltaic battery to this purpose: the principal of which are, the small dimensions, weight, and cost of the magnetic exploder; that used in the experiments alluded to in the report weighed only 32 lbs. 11 oz., and all the arrangements in connexion with the instrument are so simple that any injury which they may sustain can be repaired by ordinary workmen.

The Report, we may add, is of great value to civil as well as to military engineers.

Submarine Telegraphic Cable.

From the London Chemical News, No. 57.

Dr. Fairbairn brought before the meeting four specimens of Submarine Telegraphic Cable, as constructed by Messrs. Hall and Wells. This cable has a copper wire insulated by india-rubber in the centre for the transmission of the electric current. Outside of this are twenty longitudinul strands of hemp steeped in pitch and cork-dust and eight steel wires braided together with twenty-four strands of hemp saturated with Stockholm tar. The specific gravity of the cable in sea-water is 1·4 and its weight in air 0·82 ton per mile. The length that would break with its own weight when suspended in sea water is 10,-810 fathoms; its tensile strength being 2·875 tons. Dr. Fairbairn presented an account of experiments which had been made on the elongation of a sample of the cable twenty feet long by the application of different tensile forces. With a force of 4480 lbs. there was an elongation of half-an-inch, and after the weight had been removed the cable was found to be permanently stretched $\frac{3}{16}$ths of an inch. With a force of 6440 lbs. the cable broke after having stretched $1\frac{1}{16}$ inches.—*Proc. Manch. Lit. & Phil. Society, Dec.*, 1860.

Wood's Fusible Metal.

From the Lond. Chemical News, No. 68.

Lipowitz has made some experiments on the cadmium-alloy, described by Dr. Wood (see *Chemical News*, vol. ii., p. 257). He found that an alloy composed of 8 parts lead, 15 parts bismuth, 4 parts tin, and 3 parts cadmium, possessed the following properties:—It is permanently silver-white, and has a brilliant metallic lustre; it is not so brittle or hard but that it may be obtained in thin leaves or flexible plates; it has a fine-grained fracture, and may be filed without stopping up the file. In dry air it keeps its polish. It expands in cool-

ing, but not so much as bismuth or antimony. Its specific gravity is from 9·4 to 9·41. It softens between 131° and 140° Fahr., and near 140° becomes perfectly fluid. No change in the condition of the metallic mass was observed on remelting after rapidly cooling the alloy. The above properties show that the alloy may be applied to some useful purposes. It may supersede all the quicksilver alloys for stopping teeth: it may be used as a solder whenever the metals soldered are not likely to be exposed to heat. Tin, lead, and Britannia-metal may be soldered together under water above 160° Fahr. Zinc, iron, copper, and brass may also be soldered with the greatest ease under water to which a little hydrochloric acid has been previously added. The alloy is so easily fusible that it may be melted on a piece of paper over a spirit lamp. In the preparation of the alloy, the author recommends the use of the purest bismuth.—*Dingler's Polytech. Journ.*, Bd. clviii. s. 271 and 376.

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM MARCH 1, TO MARCH 31, 1861.

Aerometric Balance,	J. A. Gridley,	Southampton,	Mass.	26
Agave Plant,—Dressing Leaves	E. J. y Patrullo,	Merida,	Mexico,	5
Air Engine,	J. J. E. Lenoir,	Paris,	France,	19
Alarm Trunks,	C. W. Taylor,	Pittsburgh,	Penna.	19
Anchor,	Ferdinand Martin,	Marseilles,	France,	19
Aquariums,	J. A. Cutting,	Boston,	Mass.	12
Artificial Teeth,	A. M. and J. L. Asay,	Philadelphia,	Penna.	26
Ash-sifters,	L. F Frazee,	Tottenville,	N. Y.	19
Augers,—Hollow	Wyckoff & Stevens,	Elmira,	"	12
Bandages,—Obstetrical	Martha Willis,	Rochester,	N. Y.	26
Bank Notes,	John Murdock,	City of	"	26
Barometers,—Packings for	J. P. Simmons,	Fulton,	"	12
Bed Foundation,	W. A. N. Long,	Fisherville,	N. H.	26
Bee-hives,	Daniels & Cobb,	Woodstock,	Vt.	12
———	E. L. Jinnett,	Vermillion co.,	Ill.	19
Belt Fastening,	G. W. Blake,	E. Pepperell,	Mass.	26
Blowers,	T. H. Willson,	Harrisburg,	Penna.	26
Boiler,—Culinary	T. D. Ingersoll,	Monroe,	Mich.	26
Bonnets,	Lyon & Doubleday,	Brooklyn,	N. Y.	19
Boots,—Crimping	L. W. Hayden,	Wilkesbarre,	Penna.	12
Boots & Shoes,—Apply. Heels to	Jacob Jenkins,	Lynn,	Mass.	12
———,—Trim. Heels of	C. H. Helms,	Poughkeepsie,	N. Y.	12
———,—Last for	J. H. Noyes,	Abington,	Mass.	19
———,—Tip for	G. A. Mitchell,	Turner,	Me.	12
Bottle Stoppers,	M. C. Cronk,	Auburn,	N. Y.	19
Bracelets, &c.,—Constructing	J. S. Palmer,	Providence,	R. I.	19
Brakes for Sleighs,	M. B. and S. J. Lord,	Ellsworth,	Me.	12
———,—Railroad Safety	Daniel Pohlman,	Baltimore,	Md.	19
Bread Slicer,	Alexander Dick,	Buffalo,	N. Y.	26
Brick Elevators,	Sears & Merritt,	Boston,	Mass.	19
Brush,	Daniel Fleming,	Brooklyn,	N. Y.	5
Brushes,	T. J. Mayall,	Roxbury,	Mass.	5
Butter,—Preserving	N. D. Wetmore,	Cleveland,	Ohio,	5
Butter-worker,	P. G. Woodard,	Waterford,	Penna.	19

Camera,—Oper. reflector of solar	D. A. Woodward,	Baltimore,	Md.	5
Canal Lock Gates,	Robert Taylor,	City of	N. Y.	26
Cans and Jars,—Stoppers for	J. B. Wilson,	Williamston,	N. J.	26
Caoutchouc to Cloths, &c.,	Christopher Meyer,	N. Brunswick,	N. Y.	19
———,—Vulcanizing	G. E. Hayes,	Buffalo,	"	5
Capstan,—Ships	Chas. Perley,	City of	"	5
Cartridge Boxes,	J. S. Smith,	Brooklyn,	"	12
Cartridges,—Manuf. of Metallic	Ethan Allen,	Worcester,	Mass.	12
Cheese,—Pressing	H. A. Stone,	Battle Creek,	Mich.	26
Churn,	Wm. Hamilton,	St. Catharine,	Mo.	19
———	W. B. Hopkins,	Oakfield,	N. Y.	26
——— Dasher,	M. D. Wells,	Morgantown,	Va.	19
Cigar Holders,	Michael Johnston,	South Boston,	Mass.	26
Clocks,—Calendar	Galusha Maranville,	Hampton Cor.	N. Y.	5
Corn Huskers,	G. R. Walker,	Washington,	D. C.	5
—— Planters,	John Cooley,	Tafton,	Wis.	19
—— Shellers,	Mathew Tr mble,	Princeton,	Ill.	26
Cotton Cleaners,	A. S. Eastham,	Wharton,	Texas,	12
——— Pickers,	John Griffin,	Louisville,	Ky.	5
——— Tubes,—Metallic Bands	O. C. Evans,	City of	N. Y.	26
Couplings,—Railroad Car	R. M. Hughes,	Pleasant Grove,	Penna.	5
Cultivators,	Wm. S. Riggs,	Hightstown,	N. J.	19
———	Cox & Thorp,	Three Rivers,	Mich.	19
———	Chas. Gardner,	Hoosick,	N. Y.	19
———	C. W. S. Heaton,	Salem,	Ill.	12
———	John Markel,	Monticelli,	"	19
———	W. F Quinby,	Stanton,	Del.	19
———	Frederick Stamm,	Lancaster,	Penna.	19
———	Wm. Strieby,	Wagontown,	"	12
———	J. B. Turner,	Jacksonville,	Ill.	12
Curtain Fixture,	T. G. Harold,	Brooklyn,	N. Y.	5
———	S. S. Putnam,	Dorchester,	Mass.	5
Drawers,—Substitute for	S. B. Shultz,	Princeton,	Ill.	5
Ditching Machine,	Benedict & Cummings,	Conneaut,	Ohio,	12
Dredging Machine,	S. H. Long, U. S. A.,	Alton,	Ill.	26
Dumping Wagons,	J. W. Nye,	Fairfield,	Vt.	26
Egg Beater,	Walter Hart,	Philadelphia,	Penna.	12
Envelopes,	Joseph Gray,	Raymond,	Miss.	26
Farinaceous Substances,—Desic.	Huckins & Walker,	Roxbury,	Mass.	19
Faucets,	Ralph Graham,	Brooklyn,	N. Y.	26
Fences,—Field	I. G. Inskeep,	W. Middleburg,	Ohio,	12
———,—Portable	G. B. Mallette,	Millport,	N. Y.	15
———,—Picket	G. W. T. Grant,	Winona co.,	Minn.	5
Fire Arms,	Eugene Lefaucheux,	Paris,	France,	26
———,—Loading	C. A. McEvoy,	Richmond,	Va.	26
—— Places,	B. F. Cowan,	Memphis,	Tenn.	26
Fish,—Preserving	Enoch Piper,	Camden,	Me.	19
Frames,—Turning Oval	I. P. Tice,	Baltimore,	Md.	26
Friction Gearing for Machinery,	F. P Dimpfel,	Philadelphia,	Penna.	12
Fruit,—Buildings for Preserving	B. M. Nyce,	Kingston,	Ind.	19
—— in Barrels, &c.,—Pressing	E. S. Holmes,	Wilson,	N. Y.	12
Furnaces,—Steam Boiler	J. R. Robinson,	Boston,	Mass.	19
Furnace Grates,	M. M. Rounds,	New Haven,	Conn.	12
Gas Metres,—Gearing for	John S. Elliot,	Philadelphia,	Penna.	26
—,—Naphthalizing	E. D. Kendall,	City of	N. Y.	19
Gate Hinge,	S. J. Olmsted,	Binghampton,	"	26
Gates,—Farm	Gray & Bury,	Grosse Isle,	Mich.	26
Grain Separators,	Davis & Palmer,	Hudson,	"	5
———	Gaunt & Hinman,	Keokuk,	Iowa,	19
———	Byron Rice,	Schuyler,	N. Y.	12

Hair Brush,	J. F. McClure,	Boston,	Mass.	19
Harrows,	Samuel Miller,	Winchester,	Ohio,	19
———,—Rotary	W. H. Main,	Liverpool,	"	26
Harvesters,	John Blue,	Covert,	N. Y.	26
———,—Cutting Apparatus	D. H. Thayer,	Lansing,	"	26
———,—Binding Attachm't	Clark Alvord,	Westford,	Wis.	5
———,—Fingers for	E. P. Russell,	Manlius,	N. Y.	19
Hat Bodies,—Felting	Roswell Northrop,	N. Millford,	Conn.	19
Hats,—Die for Pressing	Doubleday & Lyon,	Brooklyn,	N. Y.	5
Hemmers and Folders,	John and Francis Stevens,	City of	"	26
Hemming Guides,	Josiah Howell,	Sacramento,	Cal.	5
Hemp Brakes,	Austin & Creasy,	Carrollton,	Mo.	5
—— Carts,	Z. Feagan,	Palmyra,	"	26
Hog Cholera,—Comps. to Cure	Jacob Lighter,	Clay Village,	Ky.	19
Hogs from Rooting,—to Prevent	R. Little,	Middle Branch,	Ohio,	5
Horse-shoe Iron,—Formation of	Ebenezer Cate,	Franklin,	N. H.	26
Horse-shoes,—Forming	"	"	"	26
Hose,—Waterproof	T. J. Mayall,	Roxbury,	Mass.	5
Hygrometers,	A. H. and C. R. Black,	Indianapolis,	Ind.	26
Ice Crusher,	J. L. Rowe,	City of	N. Y.	19
Iron,—Galvanizing	Wm. Blake,	Boston,	Mass.	19
Journal Boxes,—Lining	Joseph Corduan,	Brooklyn,	N. Y.	12
Knitting Machines,	Orson Parkhurst,	Cohoes,	N. Y.	5
Lanterns,	E. J. Hale,	Foxcroft,	Me.	19
———	Hale & Atterbury,	Pittsburgh,	Penna.	19
Leather,—Splitting	J. A. Safford,	Boston,	Mass.	19
Liquids,—Decalcifying	Carlos Garcia,	New Orleans,	La.	5
Lithographic Presses,	Robert McNie,	City of	N. Y.	26
Looms,—Pickers for	Samuel Boorn,	Lowell,	Mass.	26
———	Francis Peabody,	Salem,	"	5
Masts, Steeples, &c.,—Iron	E. S. Boynton,	Alexandria,	Va.	26
Meat Chopper,	J. H. Landis,	Eden,	Penna.	12
Mechanical Movements,	Josiah James,	Ogdensburgh,	N. Y.	5
Mopholder,	Wm. R. Axe,	Beloit,	Wis.	5
Motion,—Reciprocat. into Rotary	Turner Williams,	Providence,	R. I.	5
———,—Transmitting	Mathaus Kæfer,	Factoryville,	N. Y.	5
Mowing Machines,	Rufus Dutton,	Dayton,	Ohio,	19
———	G. W. Jennings,	Boston,	Mass.	12
———	E. R. Pease,	Poughkeepsie,	N. Y.	12
Musical Instrum.,—Tuning Pins	Samuel Clark,	City of	"	5
Oil from Fish,—Extracting	A. M. Millochau,	City of	N. Y.	19
Oils,—Hydro carbon	Luther Atwood,	"	"	26
Omnibuses, &c.,—Register for	Felix Brunon,	Philadelphia,	Penna.	26
Omnibus Register,	Dawson & Weeks,	Syracuse,	N. Y.	26
Ores,—Treating Gold and Silver	Hastings & Gautier,	San Francisco,	Cal.	5
Oscillating Engines,	M. E. Bollinger,	Littlestown,	Penna.	26
Paper,—Fold. Past. and Cutting	Cyrus Chambers, Jr.,	Philadelphia,	Penna.	5
———,—Preparation of Fibre for	J. E. Malloy,	City of	N. Y.	26
Paste Boards,—Drying	J. H. Patterson,	Schagticoke,	"	26
Pins,—Device for Coating	Thaddeus Fowler,	Seymour,	Conn.	19
Planers,—Roller for Rotary	A. T. Serrell,	City of	N. Y.	12
Planes,—Attachment for Bench	L. O. Fairbanks,	Nashua,	N. H.	19
Planing Bark,—Machines for	Joseph Brakely,	City of	N. Y.	19
Ploughs,	Ballard & McClure,	Mt. Pleasant,	Ohio,	26
———	L. D. Burch,	Sherburn,	N. Y.	12
———	G. W. Depew,	Peekskill,	"	19
———	Loure Green,	Great Bend,	Penna.	19
———	Rulofson & DeGarmo,	Rochester,	N. Y.	12
———	D. W. Smith,	Dooly county,	Ga.	19
———	G. A. Walker,	Annville,	Penna.	12
Potato Diggers,	T. C. Zulich,	Schuylkill Hav.	"	5

Power,—Generating	Peter Shearer,	Reading,	Penna.	5
Press for Packing Wool,	G. M. Cooper,	Litchfield,	Mich.	26
Presses,	John Seitz, Sr.,	Bloom,	Ohio,	5
———	Roswell Wakeman,	Port Deposit,	Md.	26
———,—Cotton	P. G. Gardiner,	City of	N. Y.	26
Pressure Gauge,	John Leavens,	Brooklyn,	"	19
Printing Presses,	A. S. Adams,	Chelsea,	Mass.	19
———————	Chas. Potter, Jr.,	Westerly,	R. I.	5
Pumps,	Dennis Hayes,	City of	N. Y.	26
———,—Rotary	Hardy & Morris,	Cincinnati,	Ohio,	5
Punching Articles of Irreg. Form,	Levi Dodge,	Waterford,	N. Y.	12
——— & Shearing Machines,	P. C. Perkins,	"	"	12
——— Machine,	David Sprague,	Elizabethport,	N. J.	12
Quilting Frame, Table, &c., comb.	Bernard Fagan,	New Britain,	Conn.	19
———————	Asahel Osborn,	Morris,	N. Y.	26
Railroads,	Rowland Cromelieu,	City of	N. Y.	26
———	Alexander Hay,	Philadelphia,	Penna.	19
Railroad Cars, &c.,—Boxes for	Horace Tupper,	Buffalo,	N. Y.	19
———————,—Draught Bars	H. J. Lombaert,	Philadelphia,	Penna.	12
——— Chairs,	Archibald McGuffie,	Rochester,	N. Y.	26
Reaping and Mowing Machines,	Cyrenus Wheeler, Jr.,	Poplar Ridge,	"	12
Refrigerator,	T. W. Chatfield,	Utica,	"	26
Register,—Hot Air	J. H. Simonds,	City of	"	19
Rein Holder,	T. L. Braynard,	"	"	19
Roofing,—Metallic	W. G. Reed,	Chelsea,	Mass.	26
Rope,—Making	F. J. Miller,	Buford,	Ga.	5
Saccharine Juices,—Evaporating	Coe & Geon,	Dalton,	Ohio,	5
Safety Ships,	E. S Willson,	Saratoga Spr's,	N. Y.	12
Salt,—Drying	G. C. Robinson,	Boston,	Mass.	26
Saw-dust,—Removing	O. H. Burdett,	Moorfield,	Ohio,	26
Saws,—Hanging Band	W. H. Sullenberger,	Chambersb'gh,	Penna.	19
Saw Horse,—Wood	George Ives,	Detroit,	Mich.	5
Scissors,	A. H Knapp,	Newton Center,	N. H.	26
Screw Propeller,	A. G. Tompkins,	City of	N. Y.	26
Seed Drills,	Hiram Moore,	Fon du Lac,	Wis.	26
Seeding Machines,	I. A. Stafford,	Essex,	N. Y.	19
Sewing Machine Needles,	C. H. Wilcox,	City of	"	19
——— Machines,	J. E. Earle,	Brooklyn,	"	5
———————	W. C. Hicks,	Boston,	Mass.	26
———————	J. W. Howlett,	Greensboro',	N. C.	5
———————	J. L. Hyde,	City of	N. Y.	5
———————	George Juengst,	"	"	12
———————	Lathrop & Justice,	Philadelphia,	Penna.	5
———————	John Moulson,	"	"	5
———————	C. B. Richards,	Brooklyn,	N. Y.	5
———————	I. M. Rose,	City of	"	5
———————	N. G. Ross,	Cincinnati,	Ohio,	26
———————,—Hemmers for	Clark Marsh,	Bridgeport,	Conn.	5
Shear and Punch,	T. F. Taft,	Worcester,	Mass.	26
Shirred Goods,—Making Elastic	Richard Solis,	N. Brunswick,	N. J.	19
Shoes,—Fastening for Gaiter	"	"	"	19
———,—India Rubber	Christopher Meyer,	"	"	19
Skates,	Hiram Clark,	Rochester,	N. Y.	19
———	A. A. Gibson,	Worcester,	Mass.	26
Soaps,—Silicated	G. E. Vanderburgh,	City of	N. Y.	5
Spinning Machines,	Higgins & Whitworth,	Salford,	Engl'd,	26
Springs,—Arrang. of Carriage	Thomas Phillips,	Ann Arbor,	Mich.	26
———,—Cushion	J. W. Evans,	City of	N. Y.	26
———.—Railroad Car	"	"	"	26
Stave Machines,	Minard Snell,	Medina,	"	26
Steam Boilers,	Leon Pierre Barre,	Paris,	France,	26
———————	John Dunham,	Detroit,	Mich.	19

Steam Boilers,	John Porter,	Jefferson,	Texas,	5
—— Boiler Furnaces,	J. R. Robinson,	Boston,	Mass.	5
—— Boilers,—Indic. Water in	H. F. Hart,	Brooklyn,	N. Y.	26
——————,—Multitubular	T. J. R. Robinson,	Boston,	Mass.	19
——————,—Water Gauges	Hermann Shtarbaum,	City of	N. Y.	5
——, or cooling water,—Cond.	W. A. Lightall,	"	"	5
—— Engines,—Condenser for	J. S. Hooton,	New Carlisle,	Ind.	5
——————,—Packing for	Jesse Young,	Franklin Furn.	Ohio,	26
—— Trap,	P. D. Wesson,	Providence,	R. I.	26
—— Valve,	J. H. Scott,	Millport,	N. Y.	5
Steering Navigable Vessls,	Ross and Thos. Winans,	Baltimore,	Md.	26
Stilts,	G. N. Cummings,	Meriden,	Conn.	26
Stoves,	S. T. Harvey,	Baltimore,	Md.	19
——	M. B. Stafford,	City of	N. Y.	19
Stove-pipe Connexion,	J. H. Bell,	Chelsea,	Mass.	1
Straw Cutters,	Stuart & Stewart,	Fayette co.,	Tenn.	5
—— —— ——	G. N. and John Relyea,	Veteran,	N. Y.	19
Stuffing Boxes,	Ross and Thos. Winans,	Baltimore,	Md.	26
Stump Extractor, &c.,	J. B. Lyons,	"	"	26
Sugar Mills,	Martin Roe,	Townsend,	Ohio,	26
—— Solutions,—Evaporating	W. B. Goodrich,	Ashley,	"	12
Sweeping Streets,	W. H. Hope,	Washington,	D. C.	19
Swimming Propellers,	Jacob Kleiber,	Memphis,	Tenn.	5
Syringes,—Enema	F. B. Richards,	Boston,	Mass.	5
——————	E. G. Stevens,	Biddeford,	Me.	5
Table,	P. P. Warriner,	Holland Patent	N. Y.	12
Tanning,	A. R. Wyeth,	W. Middletown	Penna.	5
Tatting Frames,	D. F. Randall,	Hartford,	Conn.	5
Tea Kettles,	Ransom & Granger,	Albany,	N. Y.	19
Telegraph Connectors,—Joint'g	J. N. Power,	City of	"	5
Threshing Machines,—Fan Att.	Rentgen & Humes,	Keokuk,	Iowa,	26
——————,—Carrier	Godfried Weiland,	Buffalo,	N. Y.	26
——————,—Gearing	Lewis Miller,	Canton,	Ohio,	19
Time Tell Table,	Edward Roberts,	Philadelphia,	Penna.	26
Traces to Whiffletrees,—Attach.	Luther Humiston,	New Haven,	Conn.	19
Traps,—Animal	Deming & Walker,	Delmar,	Penna.	5
Trees, Wires, &c.,—Prev. Decay	Benjamin Best,	Dayton,	Ohio,	5
Trucks,—Hand	Wm. C. Reutgen,	Keokuk,	Iowa,	19
Turning Irregular Forms,	Jonathan Creager,	Cincinnati,	Ohio,	12
Type Galleys,—Locking	S. W. Brown,	Syracuse,	N. Y.	12
Valve,	Cope & Hodgson,	Cincinnati,	Ohio,	19
Valves,	Thomas Evans,	Watkins,	N. Y.	26
Vehicles,—Regulating Speed of	John Griffin,	Louisville,	Ky.	5
Ventilators for Windows,	Loudon & Iversen,	City of	N. Y.	12
Vessels,—Spring Tackle for	Wm. Woodbury,	Gloucester,	Mass.	19
Washing Machine,	C. E. Toop,	City of	N. Y.	5
Watches,—Second hand in stop	Arthur Wadsworth,	"	"	26
Water Elevators,	Anderson & Davis,	Claremont,	N. H.	26
——————	J. M. Perkins,	Cleveland,	Ohio,	5
—— Metres,	Shailer & Folsom,	Roxbury,	Mass.	26
—— Wheels,	Milton Dilts,	Columbia City,	Ind.	26
——————	James Reed,	Newville,	Ohio,	19
——————,—Scrolls of	W. H. Locke,	Canton,	Penna.	26
Windmills,	A. Giraudat,	City of	N. Y.	26
Wind Wheels,	McPherson & Harbison,	Sacramento,	Cal.	26
Wrench,	C. H. Reynolds,	City of	N. Y.	26
———,—Wagon	G. B. Phillips,	Newark,	N. J.	12
EXTENSIONS.				
Looms,—Brussel	E. B. Bigelow,	Boston,	Mass.	12
Reaping Machines (4 patents),	Eunice B. Hussey,	Baltimore,	Md.	5
Steam Chests,—Connect. Pipes	H. R. Dunham,	City of	N. Y.	26

Stone,—Cutting .	Chas. Wilson, .	Springfield,	Mass.	19
Wire Grating,—Weaving	Henry Jenkins, .	Brooklyn,	N. Y.	5

ADDITIONAL IMPROVEMENTS.

Lighting Gas,—Electric. Appar.	S. B. H. Vance, .	City of	N. Y.	12
Thills to Vehicles,—Attaching	Douglas Bly, .	Rochester,	"	5

RE-ISSUES.

Apples,—Mills for Grinding	W. O. Hickok, .	Harrisburg,	Penna.	26
Bedstead Fastening, .	E. E. Everitt, .	Philadelphia,	"	26
Faucets,—Measuring	Ira Kinman, .	Freeport,	Ill.	5
Fire Arms (4 patents), .	Merrill Pat. Fire Arm Co.,	Baltimore,	Md.	26
Gas Metres, .	C. C. Lloyd, .	Philadelphia,	Penna.	19
Harrows, .	D. W. Shares, .	Hamden,	Conn.	12
———,—Seeding	Henry Hewitt, .	San Francisco,	Cal.	19
Harvesters, .	Frederich Nishwitz, .	Brooklyn,	N. Y.	5
———,—Track Clearers for	W. F. Ketchum,	Buffalo,	"	26
Photographic Bath, .	Bernard Hufnagel, .	City of	"	19
Sewing Machines,	Elias Howe, Jr.,	Brooklyn,	"	19
Skirts,—Making Hooped .	Cæsar Neumann, .	City of	"	19

DESIGNS.

Carpets, .	E. J. Ney, .	Lowell,	Mass.	19
Clock Case, .	E. C. Brewster, .	Bristol,	Conn.	19
——— Front,	Elias Ingraham,	"	"	19
Stoves, .	A. C. Barstow, .	Providence,	R. I.	26
——— .	Horton & Martino,	Philadelphia,	Penna.	19
Stove, .	Vedder & Ripley, .	Troy,	N. Y.	5
——— .	N. S. Vedder, .	"	"	5

ERRATA.

In the article entitled Examination of some Questions relative to Transportation, published in the numbers for April, May, and June, pages 217, 289, 368, for "oil," wherever it occurs, read "coal."

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, May 16, 1861.

John C. Cresson, President, in the chair.
John Agnew, Vice President.
Frederick Fraley, Corresponding Secretary. } Present.
Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were presented from the Royal Institution, the Royal Astronomical Society, the Statistical Society, and the Chemical Society, London; La Société Industrielle de Mulhouse and la Société d'Encouragement pour l'Industrie Nationale, Paris, France; Thomas Ewbank, Esq., and Jordan S. Mott, Esq., City of New York; and Messrs. Joseph Hutchinson, Frederick Fraley, William A. Rolin, and Andrew Pallis, of Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of April was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute proposed at the last meeting (6) were duly elected.

Mr. Fraley from the Board of Managers read a preamble and resolutions passed by the Board at their last meeting, proposing an amendment in the Constitution of the Institute, which were discussed and laid on the table until the next meeting.

Prof. Cresson exhibited a lorgnette prepared by Dr. C. M. Cresson for subaqueous exploration, the peculiarity of which consisted in placing a Nicols prism of Iceland spar between the object glass and eye piece, which removed the greater part of the bright light reflected from the surface of water, and thus made objects beneath the water more distinctly visible.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

APRIL.—The month of April of this year was unusually warm. The maximum temperature (88°) was noticed on the 24th of the month. The highest point reached previously in April, during the last ten years, was 87° in 1855. The warmest day of the month was the 23d, of which the mean temperature was 73·3°.

The first day of the month was the coldest,—mean temperature 38°; but the minimum (33°) was reached on the 4th. The range of temperature for the month was 55°.

The pressure of the atmosphere was greatest (30·233 ins.) on the morning of the 1st; and least (29·213 ins.) on the morning of the 17th; making the range for the month, 1·020 inches. The mean pressure was greatest, (30·150 ins.,) on the 4th, and least, (29·342 ins.,) on the 17th of the month.

The force of vapor was less at 2 P. M. than usual. At 7 A. M. it was a little below, and at 9 P. M. about as much above the average of those hours for ten years. The relative humidity was less than usual, as will more particularly appear by reference to the following table of comparisons.

Rain fell on nine days to the aggregate depth of 4·150 inches, of which more than one-half fell from the 15th to the 17th of the month. Snow fell for a few minutes, on the morning of the 17th, and is supposed to be the last of the season.

There were but two days on which the sky was entirely clear or free from clouds, and four on which the sky was completely covered with clouds at the hours of observation.

A Comparison of some of the Meteorological Phenomena of April, 1861, *with those of April,* 1860, *and of the same month for ten years, at Philadelphia.*

	April, 1861.	April, 1860.	Apr., 10 years.
Thermometer.—Highest,	88°	81°	88°
" Lowest,	33	29	20
" Daily oscillation,	19·05	18·90	16·79
" Mean daily range,	5·85	7·40	6·45
" Means at 7 A. M.,	47·18	43·96	45·74
" " 2 P. M.,	60·55	56·56	57·74
" " 9 P. M.,	51·10	47·92	49·56
" " for the month,	52·94	49·48	51·01
Barometer.—Highest,	30·233 in.	30·303 in	30·518 in.
" Lowest,	29·213	29·319	28·884
" Mean daily range,	·143	·166	·176
" Means at 7 A. M.,	29 845	29·849	29·804
" " 2 P. M.,	29·787	29·794	29 762
" " 9 P. M.,	29·816	29·830	29·790
" " for the month,	29·816	29·824	29·785
Force of Vapor.—Means at 7 A. M.,	·231 in.	·210 in	·235 in.
" " " 2 P. M.,	·226	·234	·250
" " " 9 P. M.,	·259	·230	·253
Relative Humidity.—Means at 7 A. M.,	67 per ct	70 per ct.	72 per ct.
" " " 2 P. M.,	42	50	52
" " " 9 P. M.,	65	67	68
Rain and melted snow,	4·150 in.	3·646 in	4·884 in.
No. of days on which rain fell,	9	15	13
Prevailing winds,	s 73°30′w ·177	s 88°36′w ·250	s 70°10′w ·179

Abstract of Meteorological Observations for March, 1861; *for the County of Philadelphia, Pennsylvania.*

PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 80 feet.
Prof. J. A. KIRKPATRICK, Observer.

1861.	Barometer.		Thermometer.			Force of vapor.	Relative humidity.	Rain and snow.	Prevail'g winds.
March.	Mean.	Mean daily range	Mean.	Daily oscillation.	Mean daily range.	2 P. M.	2 P. M.		
	Inch.	Inch.	°	°	°	Inch.	Per ct.	Inch.	Direc. (var.)
1	29·802	·263	59·7	24	9·6	·418	53		s. w.
2	29·740	·085	65·0	29	4·0	·479	55		s. w.
3	29·502	·245	66·0	30	8·0	·403	42		s. w.
4	29·608	·192	54·7	19	12·7	·109	21		n. w.
5	29·903	·256	39·5	19	19·2	·074	30		n. w.
6	29·911	·137	34·0	18	5·5	·074	30		w. s. w.
7	30·244	·331	24·5	19	9·2	·118	68		n. w.
8	30·261	·178	36·3	25	10·5	·083	29		(var.)
9	29·565	·686	45·8	17	12·5	·254	80	1·245	(var.)
10	29·876	·310	47·7	9	8·2	·150	63		w. n. w.
● 11	30·129	·254	39·3	13½	4·3	·087	37		n. w.
12	29·941	·187	46·0	23	12·7	·202	48		s. w.
13	29·808	·129	48·8	17	5·0	·320	69	0·056	(var.)
14	29·988	·120	30·3	16½	18·0	·136	78	0·378	n. e.
15	29·793	·225	38·3	9	4·3	·127	60		n.
16	29·567	·188	41·3	22	8·0	·090	27		n. w.
17	29·881	·314	40·0	24	12·0	·157	52		n. w.
18	30·163	·281	23·0	14½	17·0	·087	55		n. e.
D 19	30·067	·095	24·3	13½	2·0	·070	44	0·095	n.
20	30·074	·035	31·8	19	7·5	·108	45		s. w.
21	29·692	·382	32·2	6	7·7	·106	58	0·266	n. w.
22	29·786	·102	39·0	18	8·5	·113	38		n. w.
23	29·812	·140	46·0	21	7·0	·128	31		(var.)
24	29·868	·207	48·5	12	6·5	·133	39		w. s. w.
25	30·096	·265	43·8	20	6·0	·142	35		(var.)
○ 26	29·868	·228	57·3	22	13·5	·414	72	0·106	s. w.
27	29·683	·213	54·3	15	10·3	·360	87	1·667	(var.)
28	30·026	·343	47·7	16	7·3	·142	35		w.
29	30·068	·098	52·2	22	4·5	·190	34		s.
30	29·800	·227	55·5	18	6·7	·224	40		w.
31	30·213	·413	45·0	16	12·5	·112	31		(var.)
Means	29·895	·231	42·7	18	8·7	·162	48	3·903	s 73½°w

Abstract of Meteorological Observations for March, 1861; made in Adams, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.

	Gettysburg, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs.					Chambersburg, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. Wm. Heyser, Jr., Observer.								Somerset, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. Geo. Mowry, Observer.								
1861.	Barom.	Thermom.		Rain and snow.	Prevail'g winds.	Barom.	Thermom.		Force of vapor.	Relative humidity.	Dew point.	Rain and snow.	Prevail'g winds.	Barom.	Thermom.		Force of vapor.	Relative humidity.	Dew point.	Clouds.	Rain and snow.	Prevail'g winds.
M'ch.	Mean.	Mean.	Mean daily range.			Mean.	Mean.	Mean daily range.	2 P. M.	2 P. M.	2 P. M.			Mean.	Mean.	Mean daily range.	2 P. M.	2 P. M.	2 P. M.	Sky covered.		
	Inch.	°	°	Inch.	Direc.	Inch.	°	°	Inch.	Per ct	°	Inch.	Direc.	Inch.	°	°	Inch.	Per ct.	°	Per ct.	Inch.	Direc.
1	29·367	66·3	13·7		W.	29·229	64·7	12·3	·280	40	38·3		W.	27·684	60·3	7·0	·437	68	52·0	70		W.
2	29·296	63·2	5·0		W.	29·155	64·7	4·7	·514	54	52·3		E.	27·508	62·3	3·3	·422	54	48·7	47		W.
☾ 3	29·064	63·3	4·0		S W.	28·892	64·7	4·0	·369	41	43·3		W.	27·305	61·3	1·0	·435	57	50·0	83	0·097	W.
4	29·240	49·0	14·3		(var.)	29·116	49·0	15·7	·113	29	26·3		W.	27·472	40·3	21·0	·178	55	33·0	67		W.
5	29·500	29·0	20·0		N W.	29·488	31·0	18·0	·103	52	22·3		W.	27·638	26·3	16·7	·134	82	26·5	83	0·139	W.
6	29·459	33·0	10·0		WSW	29·305	34·0	6·3	·103	45	24·0		W.	27·602	30·3	6·7	·149	70	29·0	83	0·143	W.
7	29·812	22·3	10·7		N W.	29·629	25·0	9·0	·089	56	19·7		W.	27·862	20·7	9·7	·121	75	24·3	0		N.
8	29·727	36·3	14·0		S S W.	29·547	38·3	13·3	·108	37	25·3		S W.	27·705	36·7	16·0	·165	49	31·7	40		S E.
9	29·131	40·7	10·3	1·100	N W.	28·980	48·7	8·7	·190	74	34·0	0·953	W.	27·352	34·3	7·7	·173	72	32·0	100	0·086	(var.)
10	29·487	34·7	6·0		N W.	29·336	35·0	6·7	·097	39	23·7		W.	27·064	27·0	7·3	·162	84	30·5	100	0·473	W.
● 11	29·746	29·0	5·7		N W.	29·583	32·0	3·0	·103	45	24·0		W.	27·884	24·0	4·0	·142	69	28·0	17		(var.)
12	29·505	43·7	14·7		S W.	29·369	42·7	13·3	·204	46	35·0		(var.)	27·821	44·0	20·3	·233	65	38·3	100		W S W
13	29·417	43·3	5·7		S W.	29·299	46·3	3·7	·219	54	36·7		W.	27·777	43·3	11·3	·228	76	38·0	100	0·287	WNW
14	29·573	31·7	12·7	0·300	N E.	29·402	32·0	14·3	·162	90	29·7	0·360	(var.)	27·839	34·0	9·3	·155	58	40·3	100		E.
15	29·373	32·0	6·0		(var.)	29·221	36·0	7·3	·113	42	25·7		W.	27·747	29·3	4·7	·108	51	24·3	43		N.
16	29·147	39·3	7·3		S W.	29·015	46·7	8·7	·155	35	30·3		W.	27·558	40·7	11·3	·232	60	38·0	47		W.
17	29·473	37·7	11·0		N W.	29·334	37·3	13·3	·092	34	23·3		W.	27·822	25·0	15·7	·101	59	22·8	67		N W.
18	29·770	31·3	16·3	0·040	N N E.	29·544	22·0	15·3	·089	63	19·0	0·150	W.	27·936	18·0	7·0	·097	73	20·3	70		(var.)
◑ 19	29·631	24·3	5·7		N W.	29·512	26·7	4·7	·090	50	20·3		W.	27·888	22·0	8·0	·108	51	24·3	7		N W.
20	29·599	33·0	7·7	0·020	S W.	29·360	36·7	10·0	·125	40	27·3	0·100	(var.)	27·791	28·0	8·0	·168	89	30·7	67	0·357	(var.)
21	29·350	30·0	6·7		N W.	29·204	33·0	9·0	·185	43	20·0		W.	27·744	23·3	4·7	·095	54	21·7	67	0·086	W.
22	29·472	36·7	6·7		N W.	29·316	37·3	7·7	·082	26	22·7		W.	27·869	30·0	6·7	·130	58	27·5	0		(var.)
23	29·377	44·0	9·3		S W.	29·176	48·7	10·7	·118	25	36·0		W.	27·602	44·3	14·3	·228	47	37·0	63	0·080	W.
24	29·475	41·0	11·7		W.	29·344	41·0	7·7	·103	33	29·7		W.	27·851	35·0	12·0	·084	32	22·3	47		W.
25	29·710	41·7	8·0		(var.)	29·497	47·0	6·0	·133	32	28·3		W.	27·948	47·0	14·7	·268	50	40·0	100		(var.)
○ 26	29·414	56·3	14·7		S W.	29·216	55·7	8·7	·340	61	44·3		E.	27·708	58·0	11·0	·399	72	50·3	100	0·094	S W.
27	29·263	51·7	12·3	0·450	N W.	29·115	52·3	11·3	·191	41	33·7	0·445	W.	27·652	44·7	13·3	·253	74	40·8	100	0·101	W.
28	29·675	45·0	5·7		(var.)	29·505	48·3	4·0	·217	47	36·0	0·210	W.	27·987	41·0	6·3	·214	56	38·8	53		WNW
29	29·530	51·7	6·7		S S W.	29·358	53·3	5·0	·257	43	38·7		W.	27·784	54·0	13·0	·335	47	43·3	73	0·151	S.
30	29·495	49·7	11·3		N W.	29·287	51·3	12·7	·160	41	31·0		W.	27·873	39·3	14·7	·216	91	36·7	100		W.
31	29·811	41·3	8·3		S W.	29·655	42·7	8·7	·076	23	22·3		W.	28·074	38·0	8·0	·182	61	33·3	50		(var.)
Means	29·478	41·0	9·8	2·110	s75½°w	29·322	42·3	9·2	·163	45	29·8	2·218	s88°w	27·742	37·3	10·2	·205	63	34·0	66	2·094	s87½°w

Abstract of Meteorological Observations for March, 1861; made in Dauphin, Northumberland, Centre, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.

1861.	Harrisburg, Dauphin Co. Lat. 40° 16′ N. Long. 76° 50′ W. Height, 300 feet. John Heisely, M.D., Observer.							Shamokin, Northumberland Co. Lat. 40° 45′ N. Long. 76° 30′ W. Ht. 700 ft. P. Friel, Observer.							Fleming, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 ft. S. Brugger, Obs.				Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 640 feet. Benjamin Grant, Observer.					
M'ch.	Barom	Thermom.		Force of vapor.	Relative humidity.	Rain and snow.	Prevail'g winds.	Barom	Thermom.		Force of Vapor.	Relative humidity.	Rain and snow.	Prevail'g winds.	Thermom.		Rain and snow.	Prevail'g winds.	Barom	Thermom.		Force of Vapor.	Relative humidity.	Prevail'g winds.		
	Mean.	Mean.	Mean daily range.	2 P. M.	2 P. M.			Mean.	Mean.	Mean daily range.	2 P. M.	2 P. M.			Mean.	Mean daily range.			Mean.	Mean.	Mean daily range.	2 P. M.	2 P. M.			
	Inch.	°	°	Inch.	Per ct.	Inch.	Direc.	Inch.	°	°	Inch.	Per ct.	Inch.	Direc.	°	°	Inch.	Direc.	Inch.	°	°	Inch.	Per ct.	Direc.		
1	29 ..8	62·0	10·0	·440	64		(var.)	29·072	64·0	15·2	·534	84		W.	60·0	14·0		W.	29·273	51·3	7·3	·279	67	W.		
2	29·568	63·3	4·7	·493	59		(var.)	29·014	62·7	9·3	·578	71		(var.)	61·7	4·3		W.	29·102	65·0	13·7	·432	57	W.		
☾ 3	29·316	64·7	3·3	·534	70		S W.	28·749	60·8	4·5	·636	69	0·200	(var.)	57·3	6·3	0·050	W.	29·388	52·7	11·7	·441	82	W.		
4	29·52[illegible]	51·0	13·7	·253	61		N W.	28·690	45·7	16·2	·248	77		N W.	39·0	18·3		W.								
5	29·774	34·3	16·7	·164	71		N W.	29·161	25·0	17·0	·143	79		W.	21·3	11·7		W.								
6	29·725	34·7	7·0	·158	64		W.	29·111	30·0	6·3	·150	79		N W.	29·0	3·0		N W.				·161	79	N W.		
7	30·1[illegible]3	27·3	7·3	·150	79		N.	29·475	19·3	10·7	·084	72		N W.	19·0	10·0		W.	29·653	16·3		·096	85	N W.		
8	30·053	34·3	7·0	·180	73		E.	29·481	28·7	9·3	·150	80		N E.	37·7	18·7		S W.	29·148	45·0	28·7	·145	39	S.		
9	29·396	43·3	9·7	·211	82	1·120	(var.)	28·640	39·7	11·0	·183	90	1·700	N W.	38·3	9·3	0·690	(var.)	29·046	40·0	5·7	·201	84	W.		
10	29·756	38·3	5·7	·221	82		N W.	29·135	36·0	5·7	·135	61		N W.	32·0	6·3		W.	29·398	30·0	10·0	·150	80	N.		
● 11	30·032	34·7	3·7	·172	72		N W.	29·418	27·7	8·3	·155	89	0·015	W.	25·7	6·3		W.	29·536	30·0	10·0	·114	52	W.		
12	29·798	42·0	7·3	·237	76	0·114	S W.	29·197	41·7	14·0	·296	85		E.	34·3	12·7		E.	29·200	36·7	8·0	·135	61	E.		
13				·320	86		(var.)	29·116	48·0	6·3	·347	80	0·238	E.	43·7	12·0		W.	29·311	33·7	3·0	·161	79	N W.		
14	29·875	31·3		·174	100	0·430	N E.	29·348	27·3	20·7	·135	88	0·361	(var.)	31·7	15·3	0·300	E.	29·409	29·0	4·7	·161	79	E.		
15	29·671	31·3	5·3	·172	72		(var.)	29·127	32·8	5·5	·127	60		W.	34·7	8·3		(var.)	29·380	29·0	1·3	·126	62	E.		
16	29·417	45·7	10·3	·255	66		(var.)	28·825	42·5	3·0	·177	63		(var.)	41·7	7·7		W.	29·034	41·0	12·0	·162	48	W.		
17	29·765	39·0	12·7	·162	58		N.	29·156	36·2	12·7	·156	71		W.	31·7	12·0		W.	29·555	29·7	20·0	·047	42	N.		
18	30·086	23·0	16·0	·117	76		N.	29·461	17·0	19·2	·079	70		W.	21·3	10·3		E.	29·605	14·7	6·0	·051	51	N E.		
☽ 19	29·957	29·0	6·0	·175	89		N.	29·375	24·5	7·5	?	?		(var.)	21·7	1·7		E.	29·544	17·7	3·7	·047	50	E.		
20	29·874	34·0	5·0	·198	74	0·106	S E.	29·309	27·8	8·0	·100	44		(var.)	31·3	9·7		E.	29·315	32·3	14·7	·096	35	S.		
21	29·631	34·0	4·7	·142	62		N W.	29·351	29·3	10·2	·106	58	0·200	W.	27·0	6·3		W.	29·294	28·7	3·7	·183	90	N W.		
22	29·741	40·3	6·3	·199	62		N W.	29·146	39·0	9·7	·175	66		W.	35·3	8·3		W.	29·309	30·7	2·7	·129	54	W.		
23	29·641	45·3	5·0	·389	93		(var.)	29·077	40·3	8·0	·145	39		(var.)	42·7	8·0	0·100	(var.)	29·032	45·3	14·7	·159	32	S.		
24	29·772	44·0	6·7	·196	56		N W.	29·412	38·5	13·8	·193	81		W.	35·0	15·0		N W.	29·352	34·7	10·7	·121	53	W.		
25	29·976	44·7	5·3	·241	60		(var.)	29·406	40·5	12·3	·126	36		(var.)	45·0	16·7		S W.	29·291	38·7	14·0	·136	29	S.		
○ 26				·422	87		S W.	29·125	54·3	14·2	·347	80	0·150	(var.)	51·3	6·3	0·120	(var.)	28·973	59·0	10·3	·342	53	S W.		
27				·406	87	0·696	S W.	28·920	52·3	9·7	·422	87	0·438	W.	46·3	13·0	0·100	N W.	29·080	40·0	19·0	·150	63	W.		
28	29·943	47·3		·267	66		(var.)	29·337	44·3	8·0	·220	63		W.	46·3	9·3		W.	29·523	38·0	4·0	·123	48	W.		
29							N W.	29·317	52·2	7·8	·434	80		(var.)	53·0	8·7		S W.	29·060	58·3	20·3	·279	58	S.		
30	29·696	51·0		·452	94		N W.	29·057	48·5	9·0	·294	79	0·177	W.	45·3	20·3		W.	29·373	37·7	20·7	·172	72	N W.		
31	30·102	44·7	9·7	·256	71		(var.)	29·488	42·7	5·8	·248	77		W.	38·3	10·3		(var.)	29·092	35·7	2·0	·129	54	N E.		
Means	29·771	42·5	7·9	·259	74	2·466	N 64°W	29·176	39·2	10·3	·237	72	3·479	N 74½°W	38·2	10·3	1·360	N 82°W	29·333	37·6	10·5	·172	60	N 77°W		

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